AN INVESTIGATION OF THE EFFECTIVENESS, SELECTION AND EVALUATION OF NAVY EXPLORATORY DEVELOPMENT PROGRAMS

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THESIS

AN INVESTIGATION OF THE EFFECTIVENESS,
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by

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I. INTRODUCTION

There has never been a period in history in which the determination of the worth of programs within the Department of Defense (DoD) structural framework has been so critically viewed. Adding to this observation is the discernible fact that relative budgets within the Research and Development (R&D) Program are steadily decreasing.

This concern encompasses total system acquisition, operations and maintenance, hardware and software development, concept feasibility, pure research and all other programs intermediate. Further, the concern is broad-based to the extent that it has become a prime distress not only to the government sector of DoD, but also to the supporting industrial counterparts.

Owing to the desire then to better justify on-going programs, to promote innovation and concentration on highest leverage opportunities, to expedite the transfer of technolgy and projects to advanced development (category 6.3) and use of new technical capabilities developed in research (category 6.1) and to demonstrate relevance and cost effectiveness, the Research and Development program in total is currently undergoing a modification of the existing management planning system, particularly the Exploratory Development Program (EDP).

The objective of this paper then is really twofold: (1) to investigate the changing structure, organization and underlying rationale of the Exploratory Development Program

in the Navy and (2) to investigate the processes of program selection, review and evaluation as applied to technology programs within the EDP. Included will be a brief on the development of the EDP, a treatise on why it is a necessary and contributing element of R&D and also a discussion of what the future might hold for determining the "worth" of technology type programs.

Because of the significance placed on an understanding of the operations of the EDP as a necessary and crucial prerequisite to developing a meaningful evaluation methodology, the majority of this paper is focused on identifying the foundations and workings of the newly revamped Exploratory Development Program. This understanding is essential before any succinct attempt can be made to alleviate the discrepancies in the review and evaluation techniques, existing today. Hopefully, a closer interpretation of the EDP will facilitate a more viable methodology for determining the Return-on-Investment (ROI) of future technology programs within DoD.

II. BACKGROUND

A. THE TECHNOLOGY BASE

Somewhere between basic Naval research on one end of the Research and Development (R&D) spectrum and full scale development on the other, fall a great many projects which come under the heading of applied technology, or technology base programs. The technology base is the total reservoir of organized knowledge from directly and indirectly sponsored basic research into physical and social phenomena and the feasibility of new processes, techniques and components for using them (Ref. 1). Its end result is new organized knowledge. The base also retains fallout information and contributions left over from exploration and development of specific systems. The creation and exploration of candidate systems, in turn, is shaped by the information available from the technology base.

One of the largest and perhaps most dynamic businesses in the United States today is that dealing with the acquisition of major weapon systems for the Department of Defense. Due to the size and complexity of the federal government and its associated agencies, management of the affairs of this organization requires a tremendous amount of activity and coordination.

This business entity, not unlike any other, maintains a growth posture made possible by both internal and external influences. These influences are visible through the technology development programs supported by the organization. Thus,

a most important faction of the R&D community within the Department of Defense (DoD) is that responsible for developing and maintaining a strong technology base.

The technology base is supported by both Government and private activities. Private groups (such as industrial companies) and nonprofit organizations (such as Federal contract research centers and universities) both contribute to the technology base and recommend technology base programs, just as do the federal laboratories and other supporting agencies.

Within DoD, the defense laboratories are charged with maintaining the technology base by sponsoring activities in support of potential systems. Laboratory research objectives are planned to generate better technological tools five to twenty years in the future. There does indeed exist a requirement for the technology to be related to mission/operational needs.

Due to the seemingly nebulous nature of these technology oriented programs, a great deal of scrutiny has been, and continues to be, given them, with primary emphasis of the concern aimed at their resultant value. Because of the presence of intangible outputs in the sense of quantification, coupled with an evidence of decreasing relative budgets, technology administrators at all levels within the command have been, and continue to be, faced with the dilemma of determining which programs should receive their attention. Their problem is essentially twofold: (1) How are they to determine which of the many proposed (alternative) programs should be selected for support, and (2) how are they to evaluate the effectiveness of their programs?

It is very difficult to know how much should be spent for technology base activities because payoffs are virtually unpredictable and only rarely are they realized at some future date in a directly traceable manner (Ref. 1). Operational needs can be met most effectively at the lowest possible cost by innovative products built on new technology being created for its own sake (pure technology) as well as that which remains as fallout from other system efforts (applied technology).

A significant problem in defense has been to control the relationship between technology base activities and system acquisition programs. Technology base projects have gone on to develop more than just the raw elements and material to meet as yet unexpressed needs. Traditionally they have developed subsystems and system concepts independently of specific needs. Once developed, subsystems have sought out homes in new system candidates and systems in turn have searched for a need they could satisfy. Further, these subsystems have been old technologies extended to improve the performance of old kinds of products.

There is a common misconception that defense systems have suffered because they have embodied too much "new technology" and, as a result, have become too complex, sophisticated and expensive (Ref. 1). The explanation for this is that what is "new" about "new technology" is the higher level of performance demanded from the old technical approaches. In fact,

subjective ratings have indicated that systems, while becoming more complicated and expensive, have become less technologically advanced.

Applying new technology to meet more stringent needs can, in fact, result in simpler, less costly systems. As a common example, the transistor development has markedly reduced the cost and size of electronic systems and improved their reliability, maintainability and other cost of ownership factors.

The need for an active and viable technology base is thus extremely important. The larger the span of technical and scientific activity sponsored by the Government, the more extensive will be the optional technological choices available to the system designer. It is imperative that cost-benefits be maximized in providing the technology base for new systems. This then can only be realized when the base program is driven from operational needs and mission requirements. This, in turn, requires a most judicial and expedient methodology for determining the criteria for the selection and evaluation and the effectiveness of the technology base programs in the R&D environment.

Just as critical as a well defined and operable methodology for determining selection and evaluation criteria, is the understanding of the actual program, or system, which is to be operated on. No attempt could ever be made to determine a program's worth, or return on investment (ROI), without a prior and thorough understanding of the functions and underlying philosophies of that program. It is crucial that a sound

foundation be established from which goals and strategies can be derived rather than the traditional dollar value of output.

B. THE EXPLORATORY DEVELOPMENT PROGRAM AS THE CRITICAL LINK

While many definitions of exploratory development exist, there are several functions that should be fulfilled by this category of Research and Development. These might be grouped into the following areas;

1. The translation and application of research results to practical use, including the formulation of new technology areas.
2. Feasibility demonstrations of component and system hardware concepts.
3. Applications of new technology to existing components or systems.

The nature of the preceding functions implies that both the inputs and outputs of exploratory development are quite varied, and can be thought of as a continuum. Maximum benefit in an Exploratory Development organization would appear to accrue from having the continuum functions in close proximity.

The purpose of the Exploratory Development program as delineated by NAVMATINST 3910.7B of 3 October 1974 is as follows:

> The purpose of the Exploratory Development program is to develop the technological wherewithall to solve specific Navy and Marine Corps problems, and to identify and exploit new technological opportunities which may stimulate new operational concepts within the operating forces. It is the policy of the Chief of Naval Development that the program include concept formulation effort

in the form of analytical and experimental effort to help identify problems, determine alternative solutions thereto in terms of prospective systems, sub-subsystems and techniques, and demonstrate the technical feasibility of those solutions to a degree which warrants their consideration for support under Advanced Development. Selectively, where a system or subsystem is relatively small and of low technical risk, the program may support effort aimed at acquiring information prerequisite to commencement of Engineering Development. Such effort, however, should stop short of engineering refinements characteristic of prototyping development for procurement, inventory or operational deployment. While the program may also encompass analytical and experimental work on the technologies directly related to materials, components, processes, techniques, and individual equipments of Navy and Marine Corps interest, broad-based investigations in physical, biological, environmental, medical, behavioral, social and engineering sciences characteristics of the Naval Research program are not permitted. Effort of an exploratory nature, which has a primary purpose of direct support of specific Advanced, Engineering or Operational Systems Development projects should be funded and accomplished as an integral part of those projects, subject to close coordination with related effort in the Exploratory Development program.

The operation of this system has several characteristics that are significant in the management of applied technology (category 6.2) programs (Ref. 2).

- Very broad technological base requiring judgements and technical expertise in many fields at all levels of control.

- Many layers of control--DDR&E, ASN (R&D), CND, SYSCOMs, Offices, DLP, DNT, laboratories--and necessity for coordination of tasks with related programs as well as with pure research (category 6.1) and advanced development (category 6.3).

- Coordination necessary between services and with the industrial complex.

- Results of program efforts are seldom visible or recognized in the system that reaches operational use.

- Categorization of tasks is not easily relatable to naval responsibilities, missions, operational concepts, or systems.

● CNO's guidance on Naval needs is not directly translatable into R&D requirements. CNM does not interpret operational needs for SYSCOMs. Each SYSCOM (and suborganization within SYSCOM) employs a different subjective means in defining R&D goals. There is no priority assigned to individual tasks.

● The system creates a large number of low level funded tasks (approximately 650 Task Area Plans (TAPs) (DD1634) yearly).

● Approved TAPs can be underfunded or not funded at the discretion of SYSCOMs or laboratories without reference to CND or DNT.

● Reductions in funding are frequently made by proportionate cuts which results in perpetuation of sub-critical programs and reduced effort on critical programs.

● Excessive effort is devoted to making minor changes in funding levels with resulting turbulence.

● Inordinate effort is devoted to management, funding changes and justifications of programs which takes technical personnel away from productive tasks.

● The system fosters "micro-management." Program reviews frequently do not result in "make-a-difference" changes.

● Protection of in-house effort emphasized as contrasted to contractor effort.

● Delay in exploiting available technology.

● Overemphasis on evolutionary and fix-it projects.

● Inadequate scientific and technical advice in specialized fields involving programs of several organizations.

● Critical problems exist related to coupling the 6.1, 6.2, and 6.3 programs to initiate an Engineering Development (6.4) program.

It thus becomes evident that a crucial prerequisite to any understanding of the methodologies of Exploratory Development program selection and evaluation is a thorough understanding of the program itself. For this reason, and owing to the fact that EDP is at this time undergoing major organizational and structural revision, a significant amount of

attention is shown this subject in this thesis. The EDP is indeed the "critical link" in terms of developing major weapon systems within the Department of Defense, and understanding the functions and operations of it are also critical in terms of measuring program worth. The changes in the program have been initiated in an effort to alleviate the negative aspects of the previously mentioned characteristics of the program operation. It is felt that only through an understanding of the function/operational aspects of the EDP can the concept of Return-on-Investment be addressed, since this must ultimately be linked to the organizations' goals and strategies rather than dollar value of output.

III. EXPLORATORY DEVELOPMENT PROGRAM

A. A RATIONALE FOR A POLICY PLATFORM

Because of the tremendous size and complexity of the Federal Government and its many associated agencies, management of the affairs of this organization constitutes a very significant amount of activity and coordination. Accordingly, a great deal of scrutiny is given the policy platforms and expenditure characteristics within sub-organizations of this complex.

This section will investigate the Exploratory Development Program within the Department of the Navy, examine the policy of the EDP and the rationale behind that policy, examine several influences which are evidenced by the technology program, and provide a personal critique of that policy platform currently existing for the EDP from the standpoint of a public procurement.

It is felt that a comfortable understanding of the EDP policy is a valuable and key element which allows a better comprehension of the significance of the EDP structural change, thus leading toward a discussion of the present program organization and characteristics. The approach then will be to first address the broader issue of external policy influences and then focus on particular program policies as delineated by the Assistant Secretary of the Navy for Research and Development (ASN (R&D)).

1. <u>The EDP as a Public Program</u>

If any government program could be labeled "public," the Exploratory Development Program must certainly be considered as a leading contender. The business of this program is certainly conducted for the general welfare of the people of the United States through the guise of building and maintaining a strong and viable defense posture. Clearly then, the output of this entity is to be labeled a public good, since it is consumed by all members of the community of the United States. The control of expenditures is governed by the internal processes within the Department of Defense (DoD), since the costs of production cannot be maintained by competitive pricing.

Because of the nature of the product in the Exploratory Development Program, the citizens do not actively partake in setting policy or in providing an oversight function. This task is left to entrusted officials within DoD, as well as the mix of activities performed. The financing aspect of the EDP comes under close scrutiny through the auspices of both Congress and the Office of Management and Budget (OMB) in the Executive Branch of government. Programs on-going must continually be justified and reviewed for content, return, applicability and need.

There is a facet of the EDP which presents itself as an externality to the private sector. This is the area which is embodied by the notion of "technology transfer." This term is used to imply that technology, as the output from a

research effort, can be utilized productively in many locations and organizations over and beyond its initial specific mission (Ref. 3). The process of technology transfer in the EDP has traditionally been one of primarily outflux from DoD.

The working policy and structural framework of the EDP is built to closely resemble a standard "rational model" organization (Ref. 4). This will become quite evident later when the working policy/critique is presented. However, implementation of this policy is probably more closely representative of the classical "bureaucratic model," with only a moderate trend toward a politically contrived system (Ref. 5).

It should be submitted that no "Operational Code" exists which might be any more distinctive than the academic models just mentioned. This hypothesis is supported by noticing the well defined organizational concepts and general propositions under which the EDP functions; high degree of standardized procedures, uncertainty avoidance, centralized policy formulation, decisions made by leaders, presence of parochial priorities, actions are organizationalized, change is definitely incremental, long range planning is prevalent, goals and tradeoffs are of primary concern, decisions are based on administrative feasibility, change is directed from higher authority and there is limited flexibility in the line functions of the organization. Additionally, one can very obviously witness well defined rules of the game, actions which come about as a result of political inducements, definite

separation and identification of chiefs and indians and much mis-communication, all of which point toward a strong influence of the political model characteristics (Ref. 4).

Having provided an overview of the structure of the EDP and its operational characteristics and public attributes, attention now will focus more closely on the particular policy of the program on which its platform is built. Any discussion of the Congressional and Presidential influences on the EDP has been negated because it is not felt to be a program, primarily because of its size and technical complexity, which lends itself to the normal control imposed by those forces. All interactions which do exist are enacted at the ASN (R&D) level, the results of which follow.

2. EDP Rationale

A review of the Navy's Exploratory Development Program by the Assistant Secretary of the Navy (R&D) led to the recent concern to re-establish the policies which are intended to govern that section of Research and Development. As a result, the ASN (R&D) has specified the policies, performance objectives, and responsibilities concerned with the overall management of the Department of the Navy Exploratory Development Program (Ref. 6).

It is the belief of the ASN (R&D) that improvements are possible in technical strategy, responsiveness to innovation, transferring results into useful applications, visibility to management, and demonstration of the rationale and cost effectiveness of the Exploratory Development Program and

its elements. The underlying rationale of the Exploratory Development Program is derived from the fact that this activity, like all others, must compete for its resources. This implies that the programs be continually justified in meaningful and convincing terms.

According to the ASN (R&D), to assure that the long term benefits are clear, Exploratory Development must demonstrate how it (Ref. 6):

a. Provides technical opportunities which stimulate the development of substantially improved and/or totally new operational capabilities.

b. Provides solutions to problems arising in the developmental process.

c. Provides opportunities to regain operational superiority or to exploit and enhance an existing operational superiority.

d. Provides for the transformation of new research discoveries into useful applications, and for the innovative extension of existing technologies to significantly more advanced applications.

3. Policy Formulation

Using as a foundation the principles implicit in the current operation of the Program, policies have been identified which are intended: to enhance the productivity of Exploratory Development; and to improve the ability to demonstrate the need for, and benefits resulting from, the program's activities (Ref. 6).

a. The Exploratory Development Program shall be based on a set of dynamic technical strategies designed to:

(1) take maximum advantage of new technical opportunities

(2) exploit deficiencies in opposition capabilities, and

(3) provide prompt response to perceived requirements for superior naval capability.

b. The Exploratory Development Program shall be made visible through an information system permitting technical, as well as financial audit on a current basis to cognizant levels of management. The principal intent of the information system is to permit control of the technical strategy at higher levels, facilitate execution of the programs at the most technically competent levels, and facilitate the transfer of technology to advanced development.

c. The Exploratory Development Program shall include, to the maximum extent practicable, 'block programs' which are identified with major technical strategies and under the management of an organization whose mission/product line or technical competence is most appropriate.

d. The Exploratory Development Program plan shall be consistent with overall assigned ratios of in-house to contract work for balanced utilization of the national technological base.

e. The Exploratory Development Program and its elements shall be based on a more explicit application of the return-on-investment (ROI) concept.

f. The Exploratory Development Program shall be based on cost-effective principles and shall consider, as well as budgetary implications, the potential costs of acquisition and ownership.

g. The Exploratory Development Program shall be based on providing adequate funding for effective exploitation of highest-leverage opportunities. When over-all resources are inadequate or reduced, funds required for support of such projects shall be made available through cancellation or curtailment of projects with lower promise of military worth within the framework of technical strategy.

4. <u>An Assessment</u>

In general, the rationale and the policies identified are not inconsistent with the overall policies of Fiscal and Life Cycles of Defense Systems. That is to say, the basic

questions of need, technical feasibility and funding availability are inherent in the policy information for the Exploratory Development Program. However, an immediate concern which comes to mind is whether the policies, being quite broad and abstract by their very nature, can be supported and/or even interpreted at the working levels. This concern is not peculiar to this particular policy formulation, rather it deals with the structure of policy enactment through any large organization.

Because the policies have already been identified, the approach that will be taken now will be to address each policy statement separately and provide personal comment as deemed appropriate.

Policy A: Primarily the emphasis should be placed on the term technical strategy, as a means of assuring that the programs supported are productive, needed and will provide benefit. It would appear that a sophisticated and well-managed communication (information flow) scheme is necessary to carry out the desires of top management. Worth questioning is the productivity, however, of focusing attention on the deficiencies of the opposition to the detriment of encouraging an offensive approach. Further, to provide for 'prompt response' would necessarily imply that the corporate memory and developmental capability of the in-house sector be maintained.

Policy B: Almost without exception would there be an agreement with the notion of a needed buildup of a more meaningful information system. It is always potentially

possible though that a problem of unidirectional information flow will ultimately come into being. There also appears to be some conflict with the idea of maintaining control at the higher levels, and at the same time encouraging decentralization of the EDP. Decentralization is essential in order to promote and produce technical excellence and thus realize maximum productivity.

Policy C: There currently exists much support of the notion of 'block programming' on the basis of less duplication of efforts, greater knowledge of state-of-the-art in the particular product lines, and increased ability to select and evaluate the individual programs within the EDP.

Policy D: Clearly the bottom line here is to bolster and maintain a strong technology base, whether that be provided for by industry or in-house. An obvious question which surfaces given a predetermined ratio, is just where in the organization that ratio must be measured--for this will have a definite influence on accountability within the system. It should be realized that the ultimate decision should be one which yields the maximum advantage to the government's carrying out its mission. This philosophy necessarily requires a consensus that those goals and missions have properly and adequately been delineated.

Policy E: While the notion of return-on-investment appears relatively straightforward at first glance, its application in an area such as Exploratory Development is extremely difficult to enact. This is due to the obvious lack of

tangible, and thus quantifiable, output from the individual programs. However, in the context of wanting to maximize the benefits of the dollars invested, the concept is crucially appropriate.

Policy F: As much as is possible, attention should be given to the potential downstream costs of acquisition and ownership. It is this basis which will ultimately provide for a rational decision as to which programs will be supported in future Exploratory Development programs.

Policy G: Certainly the philosophy most often followed in practice would lead one to select those alternatives yielding the greatest leverage. Seriously questionable, however, is that portion of this policy that suggests each program be evaluated on its own merits and would be subject to cancellation if it showed less favor in terms of military work. It is of general belief (supporting that belief existing at the NAVMAT level) that in most cases, existing programs will continue to be funded unless there is obvious reason to alter that decision on the basis of either lessened or increased need.

5. <u>Concluding Comments</u>

There is a general trend in the Navy's Research and Development Program, including the Exploratory Development Program, to shift back to an originally supported organizational structure of being decentralized. This is due to a large extent to the desire to promote accountability at all levels of the R&D organization. Additionally, it is observed

that trends definitely indicate future total budgets to rise, while the percentage allocation to the Exploratory Development category will, as has been experienced in the past decade, definitely decline. As a result of this observation, it is noted that technology development is definitely <u>not</u> independent of weapon system development.

It is noteworthy in summary to exploit the underlying principles evidenced in the policy formulation for the Exploratory Development Program:

- Supportive of technological advances of fundamental importance to operational needs.
- Quest for technical and managerial excellence at all levels.
- Recognition of the necessity for both top-down direction and bottom-up inputs.
- Accountability essential at all executive levels.
- Necessity for strategies as tools to implement policies.
- Recognition that sometimes technical advance must be injected into the mainstream of the system forcibly.
- Recognition of essential need for adequate information systems to allow interaction.

While it is a rather straightforward task to outline a rational approach, it is extremely difficult, if not impossible, to encounter a purely rational organization in operation. Influences, personalities, and constraints are entirely too numerous to allow anything other than some form of an "individualized" organization to exist today, whether that organization be public, private or some mix of the two extremes.

An investigation of the EDP policy does, however, serves to provide the foundation on which its organization must be structured. Further, this foundation (rationale and policy) provides the impetus behind the current EDP modification, which is the subject matter of the following section of this thesis. It is important that the reader be aware that in addition to gaining a better understanding of the "real" system in operation today, the material presented will hopefully provide a context in which to review the subjects of program selection and evaluation in applied technology in a more meaningful manner.

B. STRUCTURE OF EDP (A CHRONICLE)

The creation of the offices of the Director, Defense Research and Engineering (DDR&E), Assistant Secretary of the Navy (Research and Development), and Deputy Chief of Naval Operations (Development) (DCNO(D)) back in 1959 set the stage for some revolutionary changes in the way R&D programs, and hence Exploratory Development programs, would be planned, justified and implemented for the next two decades. The concept of a complete R&D spectrum with basic research on the one end and full scale development on the other was inherent in the procedures of the first decade.

Technology programs were established which covered a wide variety of efforts, ranging from pure research in components and subsystems to fairly sophisticated experimental hardware. These technology programs at that time were characterized as

being comprised of projects more closely focused on end-products than research but entailing a higher level of uncertainty and lower financial commitment than full scale development.

Bureaus and offices were established in areas relevant to their assigned responsibilities. Project listings were required to be structured according to the format of Table I (Ref. 7). So for the first time, senior staffs in the Department of the Navy and the Office of the Secretary of Defense had a viable framework for scrutinizing the exploratory development effort and the funds allocated to it.

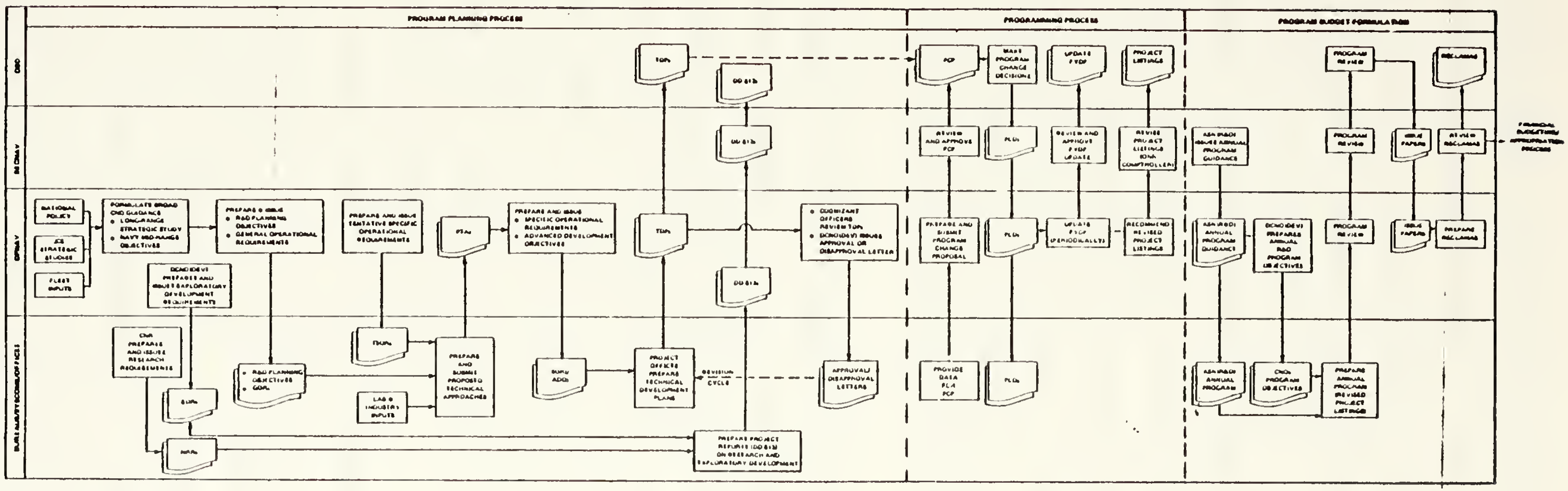
Table I Exploratory Development Functional Areas, 1962

F001	Target Surveillance
F002	Navigation
F003	Environmental Surveillance
F004	Integrated Surveillance
F005	Command Control
F006	Communications
F007	Data Processing
F008	Weapons and Ordnance
F009	Guided Missiles
F010	Jamming and Deception
F011	Naval Defense Applications
F012	Aircraft and Aircraft Support
F013	Ships and Submarines
F014	Boats and Amphibious Vehicles
F015	Logistics
F016	Personnel Administration
F017	Training

The process of planning and justifying programs in the early 1960s is broadly depicted in Figure 1 (Ref. 7). There was a trend in the early years for the bureaus and offices to

Figure 1.

R&D Program Planning and Justification Process,
Early 1960's



employ a "carte blanche" attitude to initiate new programs in response to general requirements. This philosophy began to erode, however, with the enactment of PPBS, and eventually the organization became extremely controlled, and hence, centralized by the end of the first decade.

In 1970, DDR&E then introduced two new types of documents which more clearly stressed the concern of program worth, justification and relationship to mission areas. They were called Technology Coordinating Papers and Area Coordinating Papers. They were intended to highlight program gaps, overlaps, and need for improved coordination among the Services (Ref. 8).

And so, during the early baseline period, technology programs represented a segment of the Navy's R&D program in which the management operated with little or no outside interference. Guided only by the most general requirements, bureau personnel relied heavily on Fleet and laboratory personnel, discussions with the Fleet and experience of their own officers and engineers to identify problems, initiate programs and evaluate their on-going projects.

There was a trend toward greater emphasis and dependence on the Navy laboratories, i.e., block programming. The bureau/SYSCOM point of view initially was to oppose block programming on the grounds that it amounted to delegating authority to the laboratories without commensurate accountability for fulfilling SYSCOM responsibilities. The idea of block programming has since become a reality, and is now in full effect, with nearly full support, in the Navy organization.

Block programming, as interpreted today, is a means for providing technical management in the laboratories and Systems Commands with the necessary authority (including control of funds) to plan and manage technical effort related to the pursuit of significant objectives. As will be seen later, block programming is a significant influence in the current planning and justification process proposed for the Exploratory Development Program.

C. A CHANGING CONTEMPORARY PROGRAM

The Navy Exploratory Development Program is just nearly completing a transition from a system, which has been in operation for a number of years and is relatively well known by the Navy R&D community, to a new system. Central to these modifications is the use of dynamic "technical strategies," designed to focus exploratory development more directly and visibly on Department of the Navy operational needs. The first implementation of the program utilizing these technical strategies will commence during the current fiscal year.

This program reorganization is a result of the CND/DCNM(D) having been directed by the ASN (R&D) to establish and implement a program to improve the exploratory development system, to improve higher echelons' understanding of the system and to justify 6.2 expenditures.

As indicated previously, under the former 6.2 management system the program consisted of a large number of low level funded tasks which were negotiated primarily between staff personnel of the SYSCOMs and the laboratories without

direction of either top level management or the best qualified technical personnel who are generally located at the laboratories. The relationship between funded tasks and operational needs was not altogether visible and the contributions that new technologies could make to increase effectiveness or decrease costs were not apparent. As a result, justification of the program to Congress, OSD and to ASN (R&D) was not convincing. There was a lack of funding focus on high payoff innovation and on feasibility demonstration of critical end item products. Further, there had been an inadequate interaction of 6.1 with 6.2 and coupling with 6.3 and a lack of coordination with related work by other services and industry.

The objectives of the modified 6.2 management system were then identified to (Ref. 9):

- Provide top-down direction by the use of technical strategies, prioritized technical objectives and definition of major program thrusts designed to meet operational requirements.
- Provide visibility by relating the program to Navy functions and to operational needs.
- Promote innovation and concentration on highest leverage opportunities.
- Expedite transfer of projects to advanced development (6.3) and use of new technical capabilities developed in research (6.1).
- Demonstrate relevance and cost effectiveness.

These objectives were to be achieved by clear definition of organizational responsibilities, development and execution of programs to achieve approved technical objectives, allocation of blocks of funds to organizations and delegation of

authority to implement programs to meet assigned responsibilities. CND is the designated responsible entity to ASN (R&D) for operation of the system. Appendix A is included to delineate the EDP management responsibilities, including design principles and roles of the various organizations in the 6.2 Program.

There are four basic elements of the new 6.2 planning system which utilize the technical strategy concept.

1. Direction by Technical Strategy

Designated strategists identify, define and analyze mission needs and on-going or potential technical efforts related to satisfying those needs. Mission needs are derived from analyses of threat, preferred operational concepts and system and subsystem concepts. Current programs and work by industry and other services are major factors in assessing technical potential. Technical objectives are derived from mission needs and potential technology. The strategies then are used to define the desired major thrust in prioritizing the technical objectives.

These dynamic technical strategies are designed to take maximum advantage of new technological capabilities, exploit deficiencies in opposition capabilities and provide prompt response to perceived requirements for superior naval capabilities (Ref 6). Basically, strategic planning is not a new idea, and it implies "... the process of determining the major objectives of an organization, and the policies and strategies that will govern the acquisition, use and disposition of resources to achieve those objectives" (Ref. 10).

The enactment of an Exploratory Development program policy based on the idea of technology strategies is a significant breakthrough in terms of developing a more meaningful rationale for program/project evaluation. The primary reason for this is that heretofore, organizations had neglected to recognize that there had been a definite lack of clarity in just what they were trying to measure. This belief is supported by various studies of productivity measurement and program evaluations (Ref. 11).

It should be recognized that Exploratory Development, like every other activity, must compete for its resources. Although the necessity for an extensive program is obvious to those within the RDT&E establishment, to assure maintenance at the desired level, the program must continually be justified in meaningful and convincing terms. To assure that long term benefits are clear, Exploratory Development thus must demonstrate how it:

a. provides opportunities which stimulate the development of improved or totally new operational capabilities,

b. provides solutions to problems arising in the development process,

c. provides opportunities to regain operational superiority or enhance existing superiority,

d. provides for the transformation of new research discoveries into useful applications, and the extension of existing technologies into significantly more advanced applications.

To accomplish this, then, the system being assembled at the NAVMAT 03 level addresses not only objectives, strategies and tactics (OST), but also interrelates them and

describes how the system works to harness research and development for the achievement of definite organizational goals (Ref. 12).

Essentially the OST system is based on three major ideas: (1) formulation of an OST plan consisting of a hierarchal arrangement of corporate objectives, technical strategies, and developmental tactics, (2) the super position of this organization over the normal operating organization, and (3) the use of line managers in the operating organization as action officers. Figure 2 presents this system in a somewhat simplified manner.

This current model thus contains all the elements of the historical and modern approaches, e.g., cost, timeliness, risk, weapon systems, value measures, etc., and also provides the additional and quite significant notion that the goals and policies of the organization need be accounted for.

The strategies then, as developed for the Navy EDP, will indicate allocations recommended for additional objectives with justification. DNT will provide guidance regarding overall concepts for functional areas, and also to strategists through the inclusion of relevant material from program objective memorandums.

2. Negotiating the Program

With the implementation of the new policy, all exploratory development programs will now be prenegotiated between SYSCOMs, laboratories and DNT prior to beginning each fiscal year. After the programs have been developed they then are recommended to DNT for allocation of funds.

OST STRUCTURE

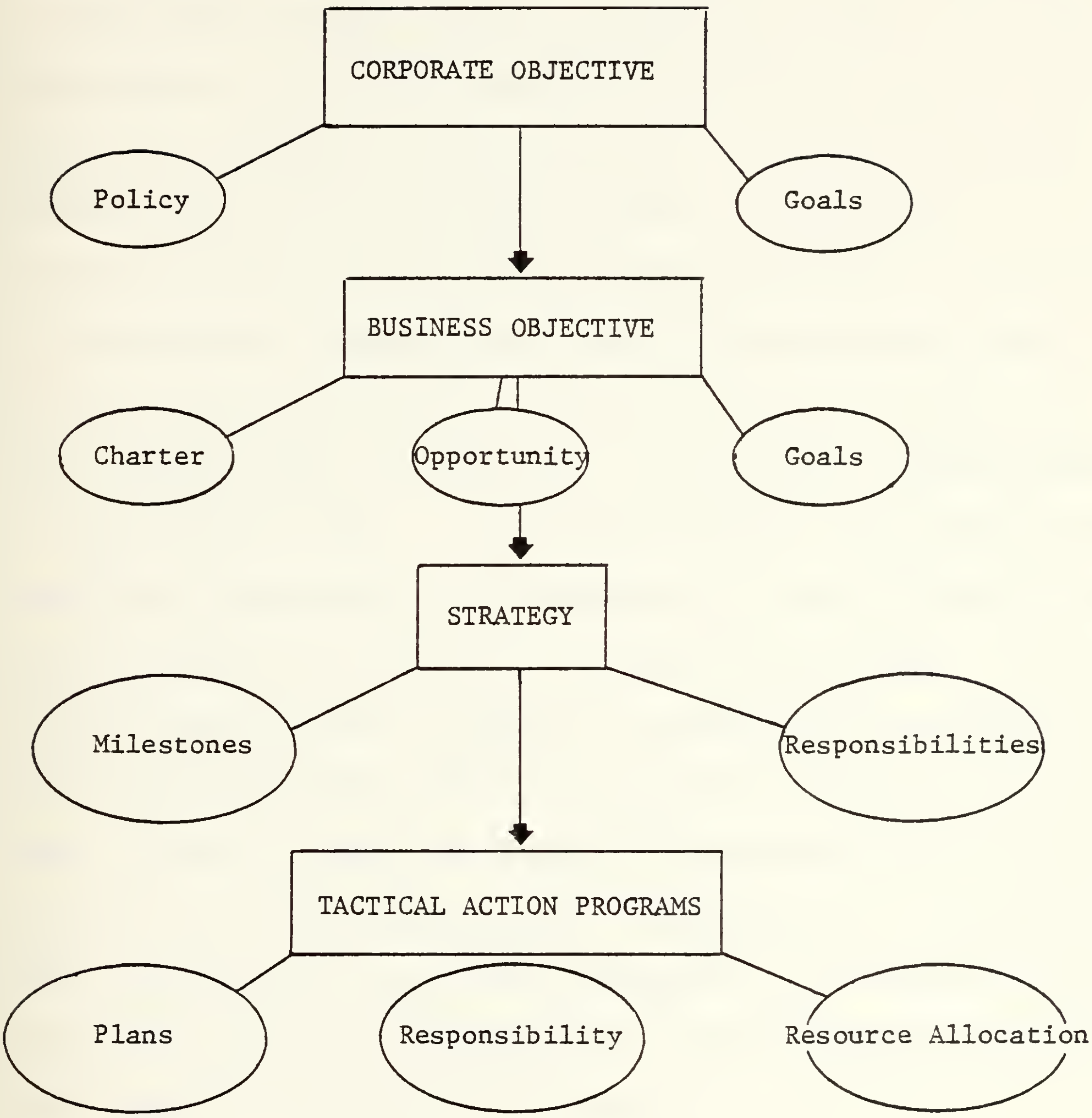
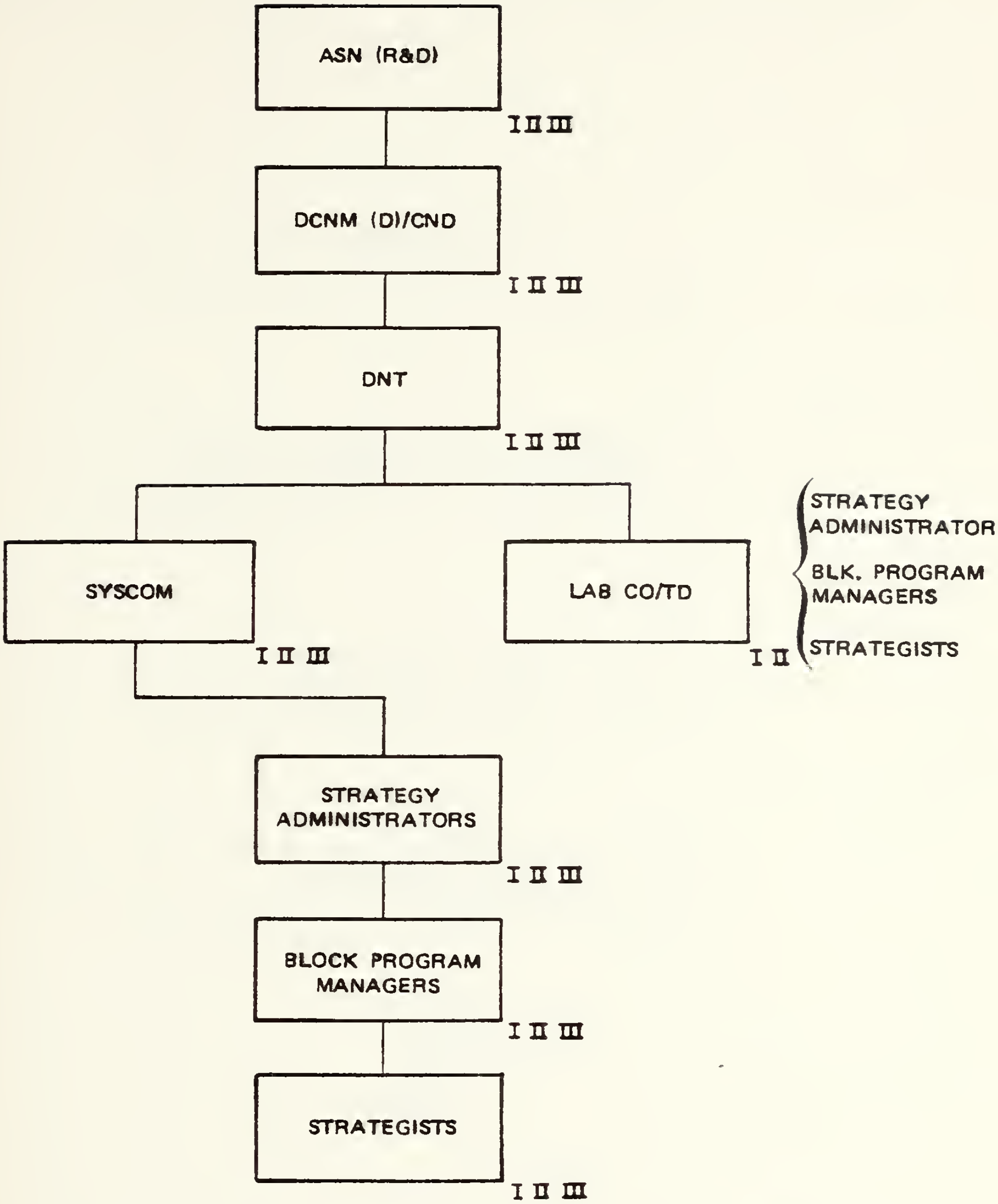


Figure 2

There are three types (categories) of programs, the characteristics of which determine how the organization will manage them. Cat I is broadbased, multi-use technology. It is negotiated between DNT and laboratory CO/TDs and funded and managed by the laboratories. All "special topic" strategy areas are included in Cat I programs. Cat II is concept-related effort for which the SYSCOMs are customers. It is concerned primarily with exploratory development of systems and subsystems concepts for accomplishing mission needs. Projects for this kind of work are negotiated between the using SYSCOMs and the cognizant laboratories. Once negotiated and approved by DNT, it is funded directly as a block to the performing laboratory which manages it. Cat III work is performed primarily by industry or other contractors. It involves primarily work related to transition of concepts to advanced development, and it is managed directly by the SYSCOMs. Figure 3 shows the "chain of accountability" which now exists in the EDP and the types (categories) or programs for which the various tiers are responsible. The planning process which has been formulated in consert with the new management system is depicted in Figure 4.

3. Allocation of Funds

Of the total funds allocated for the EDP, the Chief of Naval Development withholds a total of 15 percent of each program element to take care of subsequent Congressional cuts, to provide for new starts, for developing the strategies, for IR/IED, MAT 03 management, the Energy Office and DNT's special



I - BROAD BASED TECHNOLOGY (DNT—$→PERF. LAB)

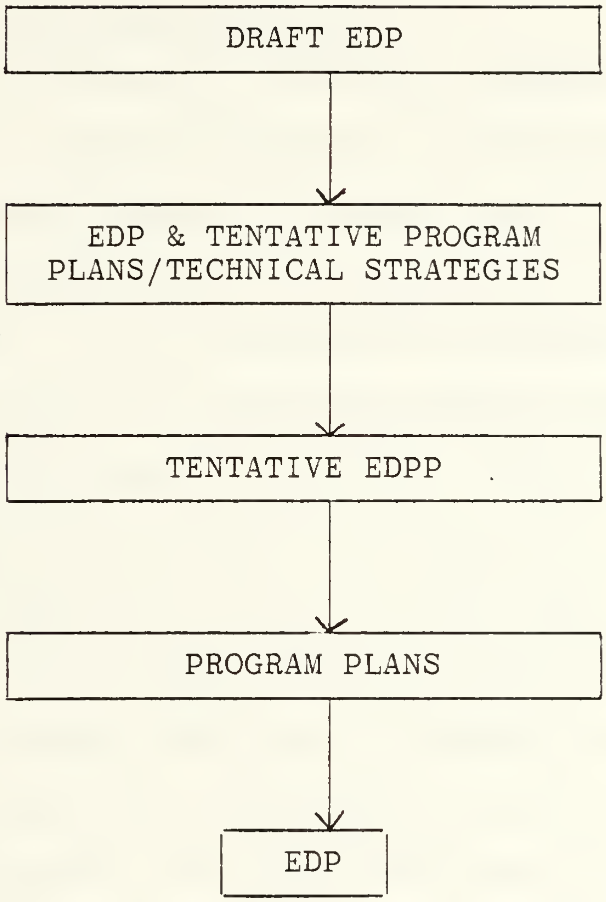
II - CONCEPT RELATED TECHNOLOGY (MAT 03T—$→PERF. LAB)

III - INDUSTRIAL 6.2 TECHNOLOGY (SYSCOMS—$→INDUST. CONCERN)

FIGURE 3. Chain of Accountability

FIGURE 4.

Exploratory Development Program Process Flowchart



projects. The bulk of the funds (roughly $2.75B yearly) are allocated to SYSCOMs and laboratories. Once the contracts for work have been negotiated, changes can be made only by the SYSCOMs for the CAT III programs and TD of laboratories for CAT I and II programs. Final approval, as before, always rests with the Director of Navy Technology.

4. Review and Evaluation

The review and evaluation focuses on two major issues: (a) were the resources actually utilized as covered in the approved program as amended and (b) to what degree were the technical objectives developed by the strategies accomplished. It was perceived by management that the basic review and evaluation questions should focus on contributions to future Navy operations and cost effectivensss. At the time of research gathering for this paper there were no details available as to how the review would be conducted but the objective is clear--substantive evaluation from the viewpoint of Congress, DDR&E and ASN (R&D) and not micromanagement. It is anticipated by EDP management that program administrators, strategists, and a qualified panel of independent individuals with knowledge of Navy needs, and other Federal and industrial efforts would be involved in review and evaluation process. However, it should be noted again that no clear and definitized methodology yet exists to conduct a complete program selection, review and evaluation program (Ref. 9).

5. Operation--Correlation of Elements and Strategies

In development of the strategies, the program element titles, which had been originally listed by the CND, were expanded to the current total of 37 (Ref. 9). Although this increase facilitated submission by the cognizant internal agency, its effect is to fracture the program and make more difficult their aggregation in an overall plan. Figure 5 shows the relationship which now exists between program elements (PEs), technical strategy areas and the Science and Technology Objectives (STOs). It is noted that there is a high degree of correlation between PEs and strategies except in sea control and power projection where the strike warfare, countermeasures and two other program elements are split between sea control and projection.

The Chief of Naval Development establishes and promulgates the structural framework for planning, programming and budgeting the EDP (Appendix B). This structure provides the link with DoD Program elements, defines the scope of work within specific areas, and identifies the organization within the Navy responsible for the planning, programming and budgeting. Appendix C is included to provide clarification of the fundation of the Exploratory Development program by delineating its new structural framework.

The system described above is new this current fiscal year. It is quite naturally going to involve a great deal of "negotiating" between the staffs of NAVMAT, laboratories and SYSCOMs, along with DNT, CND, and ASN (R&D). It is essential

Figure 5.

Relationship Between Program Elements, Technical Strategies/Substrategies, and STOs

CURRENT PROGRAM ELEMENTS	PROPOSED TECHNICAL STRATEGY AREAS	SUBSTRATEGIES*	OP-98 SCIENCE AND TECHNOLOGY OBJECTIVES (STO)
	SEA CONTROL		
Surface/Aerospace Target Surv. Strike Warfare Weapon Tech. Missile Propulsion Tech. Countermeasures Tech.	Anti-Surface, Air & Space Warfare	Sea Launched AA High Powered Radiation Sea Launched Anti-Ship Air Launched Anti-Ship Ocean Surveillance	Anti-Air Warfare Anti-Ship Warfare Ocean Surveillance
Undersea Target Surv. Undersea Warfare Weapon Tech.	Anti-Submarine Warfare	Sea Launched ASW Air Launched ASW Non-Acoustic ASW Undersea Surveillance	Anti-Submarine Warfare
	Coastal & Mine Warfare	Coastal Warfare Special Warfare EOD Mine Countermeasures Mining	Special Warfare Mine Warfare/Mine CM
	POWER PROJECTION		
	Amphibious Warfare	Amphibious Warfare	Amphibious Warfare
	Strike Warfare	Tactical Warfare Ashore Defense Penetration Ashore Air Launched AA	Tactical Warfare Ashore Sea-Based Strategic Warfare
	MOBILITY		
Aircraft	Air Vehicles	Air Vehicles & Structure Air Propulsion & Machinery	
Ships, Subs, & Boats Nuclear Propulsion	Surface & Undersea Vehicles	Surface/Sub Vehicles & Structure Surface/Sub Prop. & Machinery Nuclear Propulsion Ocean Engineering Fire Protection	
	MISSION SUPPORT		
Command & Control Tech.	C^3	C^3	C^3
Logistic Tech. Energy & Environ. Protec.	Logistics & Facilities	Logistics Facilities	Support, Logistics & Underway Replenishment
Human Resources Training & Human Eng. Tech. Biomedical Tech. Chemical & Bio. Defense Tech.	Personnel Support	Personnel Medical Life Support	Personnel/Medical
	TECHNOLOGY SUPPORT		
Electronic Device Tech.	Electro-Optics Electronics	Electro-Optics Electronics	
Ocean & Atmos. Spt. Tech.	Ocean Environment	Ocean Environment	
Material Tech.	Materials	Materials	
		TACNUC Energy Chemistry	

* Previously designated as strategy areas.

that a firm understanding of the technical strategies, functional areas and program elements be had to augment an understanding of the EDP objectives and transition steps. Only through a thorough knowledge of the inner-workings of the new system will any meaningful review, evaluation and assessment methodology be realized. As indicated, no established program or technique currently exists, but there certainly is potential for developing a viable methodology, particularly with the well structured and goal-oriented EDP which exists today.

IV. PROGRAM SELECTION AND EVALUATION IN NAVY EXPLORATORY DEVELOPMENT

With a background presented of the Navy Exploratory Development program, its functions, its responsibilities and its policies for implementation, it is beneficial to investigate now the manner in which programs have traditionally been reviewed, selected and evaluated. It would serve the reader well to keep in mind the new EDP characteristics, particularly while going through this review. This will provide a deeper comprehension of why the methodologies to be discussed were considered viable, as well as why they eventually were evidenced as not being able to adequately predict, as a management tool, as originally intended.

A. BACKGROUND

Technology base programs constitute a large number of projects in the systems acquisition process, falling somewhere between pure research on one end of the R&D spectrum and full scale development on the other. In the early years of the Navy R&D sector, these technology programs operated with little or no outside interference to the performing organization. Ideas for solving Fleet related problems and exploiting technological opportunities were converted into exploratory development projects with relative ease (Ref. 7).

In these early stages of R&D project plans, task assignments and monitoring procedures were generally flexible and

tailored to the needs of the individual managers at all levels. This process was in keeping with the "cradle to grave" concept.

More recently, a perceived need to provide guidance for technology programs was reflected in documents ranging from top level Joint Chiefs of Staff strategic planning documents to OPNAV's General Operational Requirements and CND Exploratory Development Goals. But this guidance soon tended to be either too general, providing little guidance at all, or so specific that it inhibited exploration of relevant alternatives.

Because the problems associated with this guidance and direction quite naturally are felt at all levels within the organizational structure, the problem of effective program selection and evaluation has thus remained a significant issue, particularly in the area of exploratory development.

According to a recent House Armed Services Committee report, concern was expressed that "... just spending money on research and development does not guarantee a sound R&D program or good military hardware" (Ref. 13). The committee further indicated that the Department of Defense could improve its efforts and its management through better tailored programs which would:

- Select out weapons not cost effective
- Avoid unnecessary duplication of effort
- Place greater emphasis on product improvement
- Provide more meaningful management review processes.

It is not surprising that a tremendous amount of attention is currently being given to the valuation of DoD programs in Research and Development in general and Exploratory Development in particular.

Adding now to the complexity of this situation is the fact that throughout the past fifteen years, while the total budget for RDT&E,N appropriations has been steadily increasing, the relative percentages allocated to the technology base programs (6.2 category) have been steadily decreasing. This situation is depicted in the bar chart representation of apportionments, shown as Table II.

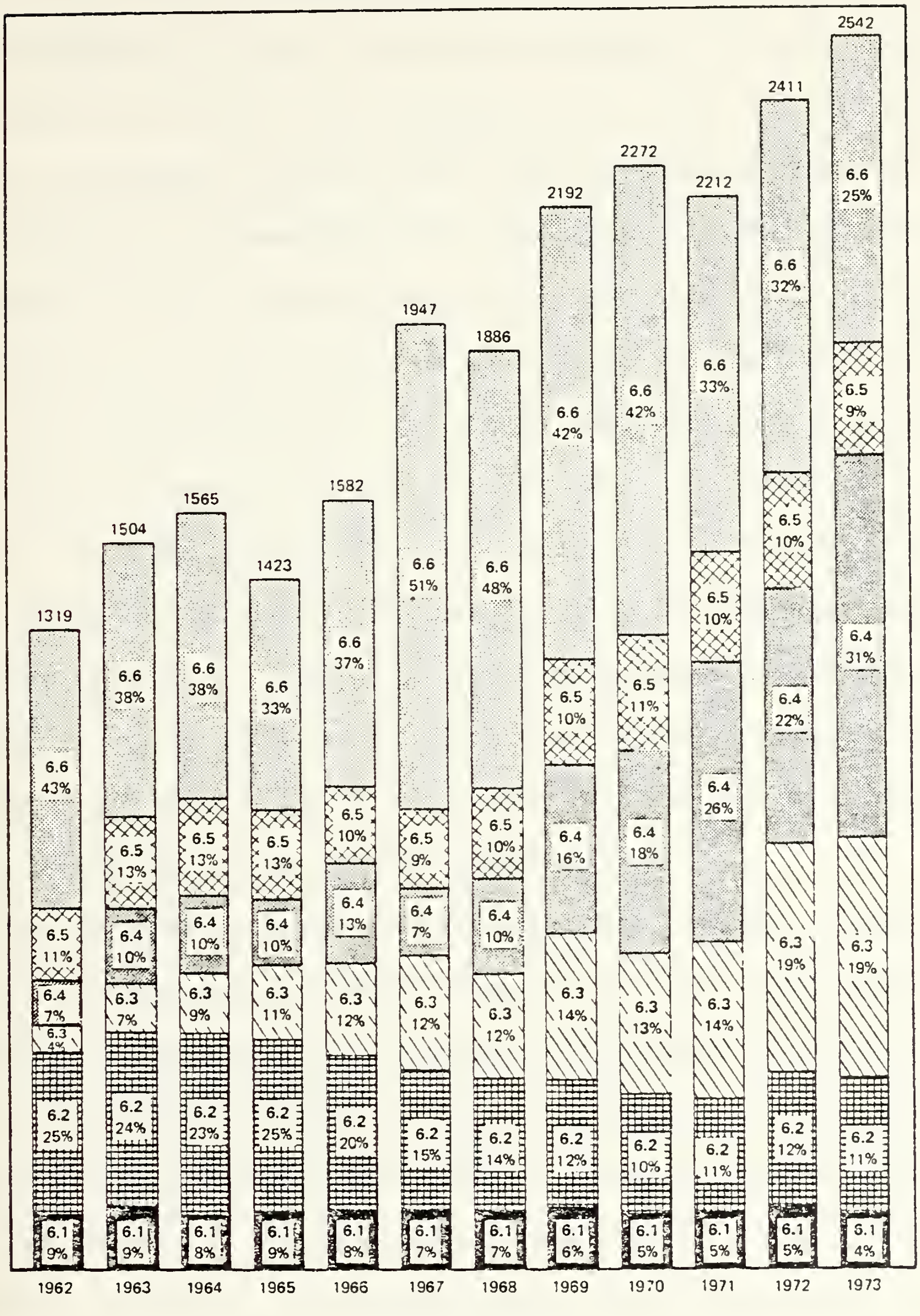
And so, just within the past decade, many scientific, and some not so scientific, approaches have been tried for potential application to technology base program evaluation and determination of return-on-investment figures. Most of these scientific techniques have been tried more at the lower echelons of the Navy R&D organization, although few have seen any real application or effectiveness. The approach currently in vogue at the NAVMAT 03 level is built around the concept of "technology strategies." There appears to be merit in pursuing this technique, at least for a selected application.

B. HISTORICAL APPROACHES

One of the early comprehensive attempts to sort, categorize and evaluate R&D selection and program evaluation techniques was that done by Baker and Pound back in the mid-sixties (Ref. 14). This article points out that most were oriented toward the operations research-management scientist, but it does

Table II

Research and Development Categories as Percent of Total RDT&E,N Appropriation FY62-FY73



Note: These amounts are derived from the past year columns of the various Congressional Budget Submissions and are not precisely consistent with New Obligational Authorizations. The difference results from reprogramming between program years, permitted in "no-year" appropriations. The data for each fiscal year's program is the latest category distribution developed for budget presentation and best reflects actual relative dollar size of the various categories for each fiscal year. FY 1962 was the first year in which this category classification scheme was systematically applied.

Source: Thomas Leckey, Assistant Comptroller for Budget and Reports ONR, in letter of 24 December 1974.

provide a sound base for presenting the early methods thought to have potential. It is interesting to note that a review of the majority of the documents reviewed in this account covering this early era indicated that very few of the techniques presented actually ever saw any relevant usage.

Keeping in consonance with the early organization and management of the exploratory development sector of R&D, project selection thus remained a relatively unstructured problem. For the most part, the early methods just did not provide an adequate description of the R&D process. At this point, it might appear feasible to question not only the predictive models but the process which the models were attempting to simulate. While it was recognized that program selection was a sequential decision making process, practicality would certainly indicate that detailed criticism of these early models would be unwarranted.

One important observation made, according to Baker, was that "...there has not been a satisfactory definition of the objectives against which a research program should be evaluated." The significance of this statement, while having clarity at this point, will take on new interpretations later in this section. Another key issue raised in these early studies, although it received little more attention than having been mentioned, was the idea that the "strategic need" somehow ought to fit into the organizational and market structure.

The methods applied in the early stages of investigation consisted almost entirely of three major methods: decision

theory, economic analysis and operations research. Table III is included in an attempt to summarize the significant features of these methodologies.

Table III

Features of Common R&D Planning Models

Feature		Method		
Characteristic consideration		Decision theory	Economic analysis	Operations research
1.	Sequential decisions	No	No	Yes
2.	Profit maximization	Partially	Yes	Yes
3.	Uncertainty (probability of success)	Yes	Yes	Yes
4.	Relationships between criteria	No	Partially	Yes
5.	Relationships between projects	No	No	Partially
6.	Optimal allocation to project	No	Partially	Yes
7.	Budget constraint	Yes	Yes	Yes
8.	Skill & facility constraints	No	No	No
9.	"Strategic need" for project	Partially	No	No
10.	Competitor efforts	No	No	No
	Area of applicability			
1.	Basic research	Yes	Maybe	No
*2.	Applied research	Maybe	Yes	Maybe
3.	Development	Little	Moderate	Definitely

*Technology base programs.

A prime observation of these methods and practices is that there exists a strong and definite need for testing to demonstrate feasibility of the predictive models. Without adequate demonstration, even the "best" descriptive models prove suspect under the close scrutiny of management.

C. MODERN APPROACHES

Once the idea that the management process of project selection and evaluation was realized to have potential as being predictable from a management scientist approach, a profuse amount of literature emerged, quite naturally. A great many new ideas were postulated, some unique in their own right, although most were merely extensions of what had already been presented in the early years.

An excellent study conducted by IDA provides an informative synopsis of the modern techniques being employed (Ref. 15). Although prepared in early 1972, the methods discussed are still being utilized, if only under slight improvement.

Because the modern techniques have tended to align themselves in the more strict, quantitative approach to program selection and evaluation, most of the discussion at this point will tend to follow along with that momentum. With the ensuing budget constraints, as previously mentioned, the patter associated with the modern approaches will necessarily allude to resource allocation as its primary objective. Realize, however, that the real issue is still the process of determining which programs are to be selected for support and how, then, can they be evaluated once initiated.

Some problems are inherently embedded in the modern methodologies, owing to their strong alliance to the quantitative approach of evaluation. A strong underlying problem is that even with modern conveniences and sophisticated analytical software and hardware, the utilization factor still

remains low (Ref 16). According to Albala in his work on stage approaches to R&D projects:

> This condition can be partly ascribed to the fact that (a) most of the proposed methods involve models requiring much quantitative input, not readily available within the company, and (b) in many instances the methods are based on techniques much too elaborate for the R&D manager's routine use.

In subtle opposition to this belief is the posture taken by Trozzo of IDA (Ref. 15.) Accordingly, Trozzo feels that:

> Development of more quantitative methods for allocating resources within Exploratory Development should continue, however, because their rigorous structure should provide (1) a useful frame of reference for organizing information and regular liaison among system specialists, technologists, and research managers, and (2) a systematic procedure for searching out a development program that will best fulfill Defense goals.

Albeit, included as Table IV a summary description of the methods used for allocating resources, taken directly from the study by IDA. Its inclusion is useful in showing the definite trend to quantitative rationale and also to demonstrate that each organization utilizes a methodology unique to its particular operation, based to a large extent on its own needs and variables.

Thus the techniques that have grown to occupy currently acceptable standards have adhered to the general conclusions of the earlier studies. To wit, there is a general recognition that each particular stage of R&D requires a set of inputs and constraints unique to its decision making process (Ref. 16). Another important observation of modern approaches is their recognition that models need be commensurate with the quality and quantity of data available. Finally, project success, to

Table IV
Summary Description of Methods for Allocating Development Resources.

Method	Primary Objective	Control Variables	Value Measures	Operational Requirements
	Devise an exploratory development program that:	Management's levers	Usefulness or contribution of program results	Major jobs of the Services
1. Industrial Analog	Resembles the pattern of technological development in U.S. industry	Funds spent in major technical areas	None	Industry groupings--weapon categories
2. TORQUE	Develops technologies having maximum "military value"	Funds to be spent in next year on project tasks	Subjective scaling of relative "military value"	Operational capability objectives (OCO's) assigned values
3. Naval Ordnance Laboratory	Develops technologies having maximum "value" for future Navy needs	Funds to be spent on each technology in next year	Subjective scaling of relative value for each factor	Warfare categories--targets--military functions assigned values
4. A.F. Flight Dynamics Laboratory	Develops technologies having maximum "military value" for the Air Force	Funds and manpower to be devoted to each exploratory development task	Subjective scaling of relative effectiveness, timing, etc.	Operations within different types of wars--assigned values
5. Cornell Aeronautical Laboratory	Consists of tasks with maximum "expected value" to the Army	Tasks that will be performed	"Essentiality" of weapons developed	No general operational requirements. Background to qualitative materiel development objective (QMDO)
6. Hercules Corporation	Contributes most to future company profits	Funds to be spent on individual development tasks	Profits generated by development work	Market characteristics
7. Army Missile Plan	Supports preferred weapon concepts projected for future deployment	Weapons and funding of requisite tasks	Discrete priorities among weapons and technical work	Operational requirements in documents by CDC
8. A.F. Directorate of Laboratories Plan	Provides the technology required for probable future systems	Technical effort in each area	None	Desired capabilities defined by OSD and the Air Staff
9. Army Research Plan	Responds to long range concepts and objectives of the Army of the future	Funding emphasis for elements of program	Priorities	Future operational needs in 56 operational capability objectives
10. Another Service Method	Supplies technical advances for fulfilling overall Service mission	Funding of individual development projects	Subjective scaling of merit of requirements and contribution of technical objectives	29 operational requirements--merit weights

Table IV (Cont'd)

	Structural Features and Factors Considered			
	Factors and Their Relationships			
	Weapon Systems	Technologies	Development Tasks	Costs
Method	Instruments for performing jobs	Composition of systems	Work to achieve desired composition	Resources consumed in work
1. Industrial Analog	Individual weapons--industry products (DoD expenditures--industry sales)	Weapon-product lifetimes and technical complexity	None	DoD expenditures in 6.1, 6.2 and total RDT&E on technical field--company funded R&D in industry
2. TORQUE	Alternative weapons for each OCO	Technological requirements of each weapon--criticality to system rated	Technical objectives sequenced in each technical requirement	Yearly and total funding for each project task
3. Naval Ordnance Laboratory	Contained in exploratory development goals (EDG) military worth	Technology pacing parameter linked to EDG by relevance measure	Implicit--different levels of pacing parameters	Aggregate expenditures on technology related to index of advance for parameter
4. A.F. Flight Dynamics Laboratory	Future A.F. flight vehicles from technological war plan--weighted for each operational requirement	Technologies linked to systems by applicability factor; separate technology goals	Confidence level gauge of achievement; contribution value links task to systems and technological goals	Funding for different levels of effort
5. Cornell Aeronautical Laboratory	QMDO description of hardware. Weighting proposed	Combinations of technologies describe possible technical approaches to subsystems	Ordered tasks makeup technical approach resource pattern	Direct funds and other resources needed
6. Hercules Corporation	Projected systems using technology; contract research--sales, margins	Substitute and complementary technolcgies in each system	Technical goals of specific organized units of effort	Funding for each possible level of effort
7. Army Missile Plan	Systems to fulfill operational requirements--priorities	Technical composition of system and subsystem concepts; general functional capabilities	Labs plan tasks for technical goals; tasks rated by contribution	Manpower, funding for planned tasks
8. A.F. Directorate of Laboratories Plan	System concept possibilities--most probable systems--subsystems	Technical planning objectives--technical gaps for systems; technical goals	Program elements--projects--tasks--technical efforts	Summary of resources for technical efforts--program elements
9. Army Research Plan	Not explicit--contained in long range technological forecast	Potential relevance of technologies in 30 6.2 elements to each OCO	237 projects in 6.2 elements; extra Army effort	Funding trends and planned support of elements--adequacy of support
10. Another Service Method	None	Technical objectives related to operational requirements	750 tasks--weights reflect contribution of each to each operational requirement	Estimated funding required to complete project

Table IV (Cont'd)

Method	Timing	Risk	Constraints	Decision Algorithm
	Time-phasing of resources and results	Probability of actual outcomes differing from expected	Limits on possible program options	Choosing pattern of development work to be done
1. Industrial Analog	None	None	None	Not specific--DoD funding proportional to industry in some way
2. TORQUE	Weapon IOC--technical objectives--funding (timeliness function)	None	Total budget	ΔValue/ΔCost in descending order among project tasks
3. Naval Ordnance Laboratory	Not explicit--progress possible in next budget year	None	Total budget	ΔPayoff/ΔCost equated over all technologies
4. A.F. Flight Dynamics Laboratory	Timing of technical objective, weighted by timeliness function	Probability that task output will fit system	Total funds, in-house and contract engineers	Linear program
5. Cornell Aeronautical Laboratory	Timing of QMDO's tasks	Probability of success for each task, technical approach, subsystem	QMDO requirements, funds, other resources	Decrease budget required by eliminating low Δ"Exp. Value"/ΔCost among technical approaches
6. Hercules Corporation	Timeliness of marketing and time required for technical goals	Probability of predicted sales, margins, research needs, technical timing, and success	Total budget	Search possible shifts of funds among projects for mix giving maximum profits
7. Army Missile Plan	Timing of funds, tasks, target dates of systems	None	None	Funds distributed down list of tasks ordered by priorities
8. A.F. Directorate of Laboratories Plan	Desired capabilities set out in five year increments	None	None	None
9. Army Research Plan	Operational requirements out to 20 years; development program in next 1-5 years	Implicit--funding that gives reasonable probability of reaching technical goal on time	In-house capability, external efforts, directed work	Qualitative analysis of shifts in emphasis warranted from priorities, relevance, support
10. Another Service Method	Projects set up to support operational requirements of 1982	Probability of success of each task to reach technical objective with funds, and in time	Sponsored projects, in-house capability	Rank projects by descending exp. value/cost

a large degree, is directly correlated with the magnitude of the resources committed, which certainly should not come as any surprise.

D. IN RETROSPECT

And so some general conclusions and statements can be gleaned from a review of these predictive models. Firstly, the worth-assessment process has not really been adequately structured by the models for the specific goals and purposes of the military R&D system, particularly the EDP. To a large extent, this has been due to a generation of philosophies which restrict the options for dealing with future world situations by proposing concepts that are extensions of the current force structure and generally use the current technological approach to accomplish mission tasks. Consequently, and as previously indicated, R&D activities tend to focus on meeting system requirements rather than on generating innovative ways to accomplish mission tasks. All too often the R&D activities in the EDP which are evaluated are not independent, as is necessary for worth-assessment procedures, but are often interrelated activities. Consequently, the projects selected usually do not provide all the technologies necessary to develop and deploy a desired system.

Secondly, the models exercised did not adequately provide procedures to assure the inputs necessary to meet the assumptions and requirements of weighting criteria. That is to say, missions, goals, and operational requirements were not (are not) being defined in terms that are worth-independent (Ref. 17).

Additionally, different worth criteria and underlying assessment processes are required to assess different activities. Each model must therefore be specifically tailored to a particular activity. Then too, the cost effectiveness of actually using the models is very difficult to evaluate. The true effectiveness should generally be subjectively evaluated in terms of how useful an R&D manager finds the results.

The future of R&D planning models similar to those identified thus far is not particularly promising in light of the observed methodological problems and managerial resistance to their use. The models just cannot, or have not been able to capture all the relevant and subtle aspects of the R&D and EDP planning process. The methodological problems preclude the use of such models even as decision information systems to aid managers, since their output is highly questionable.

But organizations performing Exploratory Development within R&D must still select and evaluate among many possible activities, however. These decisions can be improved by a better understanding of both the process of innovation and the Exploratory Development planning process. It is important that organizations have systematic procedures and logical organizational structures to assure that the major planning tasks are effectively accomplished. Figure 6 has been suggested as a representative outline of the necessary elements of a contemporary planning process (Ref. 17). To develop such procedures and structures, the organization must clearly define what it hopes to accomplish by performing the exploratory development

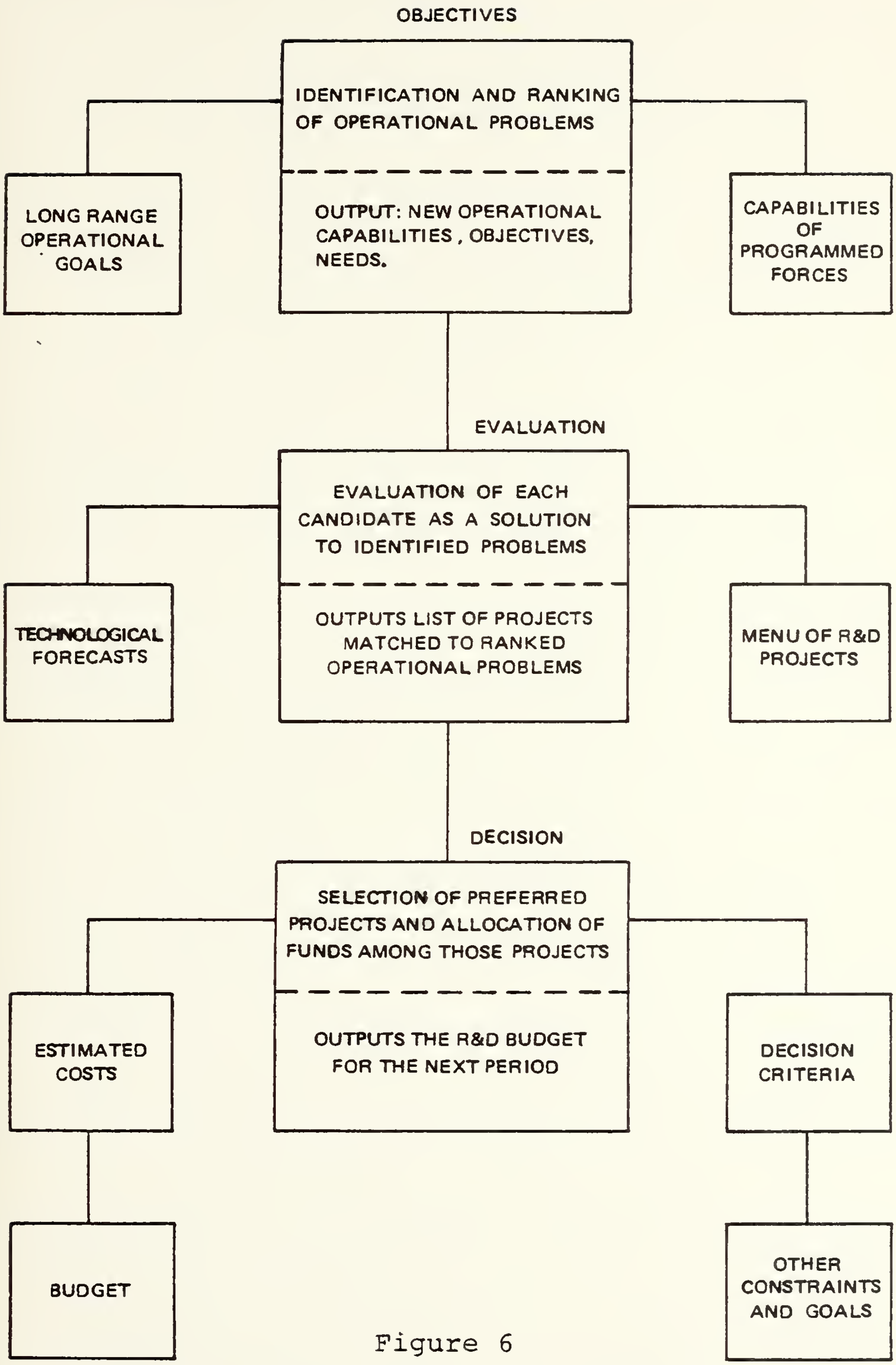


Figure 6

Conceptual outline of a long range research development planning process.

within R&D. No technique, model or methodology is likely to improve the effectiveness of a poorly or inadequately implemented planning process.

V. DETERMINING ROI IN THE EXPLORATORY DEVELOPMENT PROGRAM

It is difficult to argue with the fundamental proposition that any large enterprise ought to seek evidence of the effectiveness of existing programs and proposed program alternatives as a basic guide to decision making. Yet few sound evaluation schemes and even fewer rigorous field experiments have actually been undertaken. Serious questions exist concerning the capacity of the government both to develop and use evaluative results. Much of the concern deals with the short supply of competent policy-oriented researchers both within and outside of the government, the inadequacy of available methods and concepts for carrying out evaluative studies, and the shortage of organizations with the capacity to undertake large-scale evaluative activities.

An evaluation method based on the tools of social research has been applied successfully to social action programs to determine program effectiveness. The basic principles of this methodology, while developed originally for social and education programs, actually are oriented toward any action program which can attest to a sound platform of goals and objectives. Thus, there appears to be a potentially viable technique which would be applicable to programs exhibiting outputs which present themselves in a somewhat unquantifiable manner.

This section presents an overview of the methodology, called Evaluation Research (ER), and attempts to show how it might be applied to programs within the Exploratory Development

Program. While a complete treatise and development of an evaluation study on an exploratory program is beyond the scope of this paper, it is felt that the ER technique could be applied in particular applications to yield realistic measures of effectiveness of technology programs. A presentation of the background for the basic elements of such a study follows.

A. EVALUATION RESEARCH FOR THE EDP

Evaluation is a rather elastic word but common usage would generally imply the notion of judging merit. Evaluation has frequently had explicitly political overtones. It is designed to yield conclusions about the worth of programs and, in so doing, is intended to affect the allocation of resources.

A form of evaluation, called Evaluation Research, has been devised and used in the past on social programs, although in its strictest sense is concerned with finding out how well action programs work. It represents the application of social science research methods to discover information of importance to program practice and public policy. The tools of research are applied to make the judging process more accurate and objective. The evaluation thus establishes clear and specific criteria for success.

The research process is particularly important when (1) the outcomes to be evaluated are complex, hard to observe, made up of many elements reacting in diverse ways; (2) the decisions that will follow are important and expensive; and

(3) evidence is needed to convince other people about the validity of the conclusions (Ref. 18). Clearly then, this scheme appears to have commonality with the R&D process in general and the Exploratory Development Program in particular.

The rationale of Evaluation Research is that it provides evidence on which to base decisions about maintaining, insituationalizing and expanding successful programs and modifying or abandoning unsuccessful ones. For example, the methodology of determining program selection at a laboratory Block Program Office utilizes a decision matrix, as shown in Table V, provides much of the necessary basic information for initiating an evaluation research technique. The matrix is utilized as a tool for determining which programs should be supported and continued, as they relate to mission needs. Used in this context, evaluation research is increasingly important as a source of knowledge and direction. It can be used to tell which programs work and which do not, and points the way to better formulation of policy and program. It can be even more helpful as it proceeds to identify the effects of specific strategies and components within programs and separates out those that contribute to favorable outcomes from those that are ineffective or counter productive (Ref. 18).

If evaluation and cost-benefit analysis are to have any effect on decisions, there has to be some way to move from the data to the decision--some system for transmitting information and feeding it into the decision process. The

Table V. Block Program Decision Matrix

PRIORITIES	SYSTEMS CONCEPT		SYSTEMS INVESTIGATIONS	TARGETING	GUIDANCE	WEAPON CONTROL	FUZE	WARHEAD	PROPULSION	AIRFRAME	CONTROLS/ ACTUATORS	PLATFORM INTERFACE
1	AIR-TO-AIR MISSILES	SRAAM										
3		SELF-DEFENSE										
6		ATAAM										
2		AIAAM										
3		ALRAAM										
1	DIRECT FIRE	ANTI-SHIP										
1		AIR-TO-GROUND										
3		DEFENSE SUPPRESSION										
1	INDIRECT FIRE	ANTI-SHIP										
1		AIR-TO-GROUND										
3		DEFENSE SUPPRESSION										
1	CRUISE MISSILE	ANTI-SHIP										
1		AIR-TO-GROUND										
3		ANTI-SHIP MINE										
1	TARGET ACQUISITION/ CLASSIFICATION SYSTEM	SHIP										
1		LAND										
1	ADVANCED AIRBORNE ARMAMENT SYSTEM											
2	FIRE CONTROL	NIGHT/ADVERSE WEATHER										
2		AIR-SURFACE LIGHTWEIGHT										
5		AIR-TO-AIR GUN										
5		HELICOPTER										
6	AIRBORNE GUNS	AIR-SURFACE LIGHTWEIGHT										
5		ADVANCED										
5	CLUSTER WEAPONS	ADVANCED										
5		LIGHTWEIGHT										
4	STRAP-ON G&C KITS (KMU)											
4	ADVANCED BOMB FAMILY											
4	CHEMICAL WEAPONS											

TECHNOLOGY STATE-OF-THE-ART/RISK CODES

- UC — UNPROVEN CONCEPT (COMPARABLE TO CRITICAL)
- FC — CONCEPT FEASIBLE BUT TECHNOLOGY NOT DEMONSTRATED (COMPARABLE TO SUBCRITICAL)
- TF — TECHNOLOGY DEMONSTRATED FEASIBLE BUT SUBSYSTEM NOT DEMONSTRATED (COMPARABLE TO URGENT)
- DF — CONCEPT FEASIBILITY DEMONSTRATED, READY FOR 6.3 FUNDING (COMPARABLE TO IMPROVEMENT)
- AD — SUBSYSTEM IN 6.3 ADVANCED DEVELOPMENT
- D — SUBSYSTEM IS FULLY DEVELOPED (COMPARABLE TO NO IMPROVEMENT REQUIRED)
- # — TECHNOLOGY SAME AS SYSTEM CONCEPT NUMBER #
- X — DOES NOT APPLY

SYSTEM INVESTIGATION STATUS CODES

- U — SYSTEM CONCEPT UNDEFINED
- PD — SYSTEM CONCEPT PARTIALLY DEFINED (SOME COMPONENTS DEFINED, OVERALL CONCEPT REQUIRES ADDITIONAL DEVELOPMENT)
- D — SYSTEM CONCEPT DEFINED

Planning, Programming, Budgeting System (PPBS) recently in use in DoD is such a system, but it starts with the definition of objectives rather than the delineation of goals. Providing a systematic approach to governmental planning, the distinctive characteristics of PPBS are:

1. It identifies and defines fundamental objectives and considers all activities in terms of those objectives.

2. It explicitly and systematically identifies alternative ways of carrying out the objectives.

3. It estimates the total cost implications of each alternative, looking not only at the current year but also future years.

4. It estimates the expected benefits of each alternative.

5. It presents the resulting cost and benefit comparisons for each alternative, along with identification of major assumptions and uncertainties.

PPBS is more concerned with future options than with past experience, especially when applied in the technology program area. But in estimating expected benefits, it has to derive its figures from somewhere, and this is where evaluation should come in.

B. PURPOSE OF EVALUATION RESEARCH

Evaluation research is viewed by many as a way to increase the rationality of decision making and policy making. With objective information on the outcomes of programs, wise decisions can be made on budget allocations and program planning. Programs that yield good results will be expanded;

those that make poor showings will be abandoned or drastically modified.

An evaluation study does not generally come up with final and unequivocal findings about the worth of a program. Its results often show small, ambiguous changes, minor effects, outcomes influenced by the specific events of the place and the moment. It may require continued study over time and across projects to speak with confidence about success and failure.

For decision makers, evaluation evidence of outcome is only one input out of many. They must consider a host of other factors, from public receptivity to participant reaction, costs, availability of staff and facilities, and possible alternatives. Evaluation will definitely not take politics out of the decision making process.

The purpose of evaluation research is to measure the effects of a program against the goals it set out to accomplish as a means of contributing to subsequent decision making about the program and improving future programming (Ref. 19). The measurement of the effects refers to utilizing a research methodology to investigate outcomes of the program rather than efficiency or adherence to standards. The comparison of effects with goals stresses the use of explicit criteria for judging how well the program is doing.

Evaluation research is committed to the principle of utility. If it is not going to have any effect on the decision, then it is clearly an exercise in futility. Weiss

(Ref. 19) suggests that there are probably four kinds of circumstances in which evaluation is probably not worth doing:

1. When there are no questions about the program. It goes on, and decisions about its future either do not come up or have already been made.

2. When the program has no clear orientation. Program staff improvise activities from day to day, based on little thought and less principle, and the program shifts and changes, wanders around and seeks direction.

3. When people who should know cannot agree on what the program is trying to achieve. If there are vast discrepancies in perceived goals, evaluation has no ground to stand on.

4. When there is not enough money or staff sufficiently qualified to conduct the evaluation. Evaluation is a demanding business, requiring time, money, imagination, tenacity and skill.

The all-purpose evaluation is a myth. But there are several types of uses for evaluation. Evaluation can investigate the extent of program success so that decisions such as these can be made:

1. To continue or discontinue the program.

2. To improve its practices or procedures.

3. To add or drop specific program strategies and techniques.

4. To institute similar program elsewhere.

5. To allocate resources among competing programs.

6. To accept or reject a program approach or theory.

C. ELEMENTS OF AN EVALUATION RESEARCH PROCESS

In abstract, the basic elements of the evaluation research process include (1) finding out the program's goals, (2) translating the goals into measurable indicators of goal achievement,

(3) collecting data on the indicators of the participating elements (and for an equivalent control group), and (4) comparing the data on participants (and control elements) with the goal criteria.

But this process in theory becomes much more complex in practice. A host of unexpected problems invariably arise such as:

1. Program goals are often hazy, ambiguous, hard to pin down.

2. Programs not only move toward official goals, but they also accomplish other things, sometimes in addition and sometimes instead.

3. The program is a congeries of activities, people and structures, some irrevelant.

4. The evaluation question as posed ignores the issue of why the program succeeds or fails.

Ideally then Weiss (Ref. 18) suggests the folowing as the necessary core issues to comprise the effective evaluation research process:

1. Formulate the program goals that the evaluation will use as criteria.
2. Choose among multiple goals.
3. Investigate unanticipated consequences.
4. Measure outcomes.
5. Specify what the program is.
6. Measure program inputs and intervening processes.
7. Collect and compare necessary data.

In its rudimentary form then, the evaluation process encompasses the interpretation and implementation, including the elements of policy, goals, theory, models, experiment (to check theory and provide criteria for success-failure).

The experimental model remains the ideal in evaluation methodology, with random assignment of subjects to an experimental group which is exposed to the program stimulus and to a control group which is not, thus providing the research rationale.

It collects before and after measures over a full cycle of the program and uses specified goal criteria. Its results, then, disclose the extent to which a consistent program has reached its stated goals. However, it rarely distinguishes why the observed results occur, what processes intervene between input and outcome or what the particular implications are for improving the effectiveness of the program.

The application to the EDP, however, might just provide the necessary means with which to conduct a satisfactory selection/evaluation process, ultimately yielding a rational method for determining program worth. The stage is set; what remains now is a progressive-oriented faction of the Exploratory Development Programs, willing to commit the necessary resources of time, personnel and money to explore the potential of this new technique.

VI. SUMMARY AND CONCLUSIONS

The Navy Exploratory Development Program is currently undergoing major revision to align its management planning system with the philosophies of the new wave of thinking regarding program effectiveness; i.e., to meet the Navy's basic obligation to put government resources to their most effective use in mission accomplishment.

Traditionally, technology has gone on to develop subsystems and systems concepts independently of specific mission needs. Further, rather than actively building a strong technology base through innovation, old technologies have been extended to improve performance of old kinds of products. New systems, while becoming more complex and expensive have actually become less technologically advanced.

It is recognized that it is imperative that cost-benefits be maximized on technology base programs. This, though, can only be realized when the base programs are driven from operational needs and mission requirements.

A complete and sound understanding of the functions and underlying philosophies and policies of the technology program is essential to determine that program's worth, or return-on-investment.

Sound foundations must be established from which goals and strategies can be derived to provide meaningful inputs for evaluation methodologies of contemporary exploitation, rather than basing output measures on dollar values.

In terms of the policy platform for the Exploratory Development Program, the underlying principles evidenced in the new rationale include:

- Supportive of technological advances being of fundamental importance to operational needs.
- Quest for technical and managerial excellence at all levels.
- Recognition of the necessity for both top-down direction and bottom-up inputs.
- Accountability essential at all levels.
- Necessity for strategies as tools to implement policies.
- Recognition that sometimes technical advance must be injected into the main stream of the system forcibly.
- Recognition of essential need for adequate information systems to allow interaction.

With a strong push in Navy policy to promote accountability, a more decentralized organization is developing, as evidenced by the formation of the Block Program Offices. This allows a means for providing technical management in the laboratories and Systems Commands with the necessary authority to plan and manage technical efforts related to the pursuit of significant objectives.

As a result of direction by the ASN (R&D) to establish and implement a program to improve the exploratory development system, to improve higher echelons' understanding of the system and to justify 6.2 expenditures, the Exploratory Development Program has been, and currently is being radically revamped.

Central to these modifications is the use of dynamic "technical strategies," designed to focus exploratory development more directly and visibly on operational needs. The primary objectives of the new management system are to:

- Provide top-down direction by the use of technical strategies, prioritized technical objectives and definition of major program thrusts designed to meet operational requirements.
- Provide visibility by relating the program to Navy functions and operational needs.
- Promote innovation and concentration on highest leverage opportunities.
- Expedite transfer of projects to advanced development (6.3) and use of new technical capabilities developed in research (6.1).
- Demonstrate program relevance and cost-effectiveness.

It is essential that a firm understanding of the technical strategies, functional areas and program elements be had to augment an understanding of the EDP objectives and transition steps. Only through a thorough knowledge of the inner workings of the new system can any meaningful review, evaluation and assessment methodology be realized. While no established program exists currently, there certainly is potential for developing a viable methodology, particularly with the well structured and goal oriented EDP being implemented today.

Worth-assessment processes to date have not been able to be adequately applied to the R&D structure in general, nor the

EDP in particular. This is due primarily to the traditional programs being system requirement rather than mission need (goal) oriented. Further, earlier models did not define inputs in terms that were worth-dependent because different worth criteria and underlying assessment processes must be specifically tailored to particular activities.

The future of R&D planning models is not particularly promising in light of observed methodological problems and managerial resistance to their use. The models just have not been able to capture all of the relevant and subtle aspects of the R&D and the EDP planning process.

But organizations performing exploratory development must still select and evaluate programs some way. These decisions can be improved through a better understanding of both the process of innovation and the exploratory development planning process.

New techniques and methodologies, as well as revisions of old ones, are constantly being identified, many receiving particular area utilization, which will contribute to the process of rational decision making; i.e., program evaluation and assessment. One method felt to have high potential in the exploratory development area is that called Evaluation Research. Originally developed for application to social action programs, it is best utilized in situations where sound platforms of goals and objectives can be established. Thus, there appears to be a potentially viable technique which might be applied to programs in the EPD which yield outputs in a somewhat unquantifiable manner.

The stage has been set for the design of a new methodological tool to assess the worth of programs in the EDP. A technique has been identified which has high potential. It is strongly recommended that further study be undertaken, using the background and management planning systems presented in this thesis, to ultimately demonstrate the ability of evaluation research to effectively determine a measure of worth of programs in the Exploratory Development Program.

The evidence suggests that such a tool can be realized. What is required now is to uncover a progressively oriented faction of the EDP willing to commit the necessary resources to more fully explore and demonstrate the potential of this research technique.

APPENDIX A

EXPLORATORY DEVELOPMENT PROGRAM RESPONSIBILITIES

The following delineates Exploratory Development Program management responsibilities. It discusses basic organization design principles, the responsiblities of Program organizations and officials, and the various roles played by non-NAVMAT organizations and officials in the 6.2 Program.

Organization Design Concepts. The Exploratory Development Program management system is designed to strike the best compromise between the need to administer public resources in accordance with applicable laws, regulations, and policies, and the need to provide technical management with the freedom required to hold them accountable for results. The responsibilities described for the Exploratory Development Program are based on the following design principles:

Fixed accountability. Establishing the conditions necesary to hold individual officials (as distinguished from diffuse bureaucracies) accountable is a central consideration. Prerequisites to accountability include:

a. Assigning responsibility for results to an individual.

b. Provide that individual with the necessary authority and resources to accomplish the required results. If a manager is to be held accountable, he must have the opportunity to pursue objectives by the means which he judges most effective.

c. Providing the responsible individual with the opportunity to perform by limiting the demands on his time. This includes demands by superiors and their staffs, and by other external officials and organizations.

Clear separation of responsibilities. Responsibilities for determing the objectives to be pursued, and the technical effort required to fulfill those objectives, have been clearly and deliberately separated. Although it is essential that spokesmen for these two interests conduct an in-depth dialogue in the process of defining the Program, it is important to avoid conflict of interest. In the management system described herein, technical people are not in a position to dictate "requirements," and management people and sponsors are not in a position to control the selection of technical approach.

Quality information for management. The management system has been designed to provide the ASN (R&D), CND, and lower-level officials with all the information they require to implement their Program responsibilities. The interaction of organizations generates quantitative information required for technical management to put technical resources to their most productive use, and for higher-level management to reallocate resources as required to increase overall Program output. A system of institutionalized Program Reviews ensures the quality of information provided to top management.

Management by objectives and results. The management system relies on mutually established and agreed-upon objectives and goals rather than on management by specific directives, detailed procedures, elaborate reporting systems, frequent reviews, and other close controls. Management is by "self-control" in pursuit of the most efficient accomplishments of stated objectives. Higher-level review primarily measures results achieved in relation to approved objectives.

"People information system" for coupling. The process of defining EDP projects which collectively support Department of the Navy purposes requires extensive and intimate interaction between competent spokesmen for both sponsor and performer organizations. The interaction of Technical Strategists with spokesmen for Mission Needs and with technical managers in the laboratories is a vital element of the "people information system." This face-to-face, paper-free information system provides a mechanism for the flow of information on needs and operational environment to the technical community, and for the reverse flow of knowledge about technical opportunity to the CNO/CMC staffs.

Program Management Responsibilities

Deputy Chief of Naval Material (Development) (DNM(D)/ Chief of Naval Development (CND)). As DCNM(D), this officer reports directly to CNM. As CND, he is directly responsible to ASN (R&D). DCNM(D)/CND has overall control of the Exploratory Development Program and its funds. He carries out this

general responsibility primarily through the DNT. His functions include:

a. Reviewing and approving the Exploratory Development Program Plan (EDPP) at each stage in its evolution (i.e., the Draft and Tentative EDPPs, as well as the EDPP.

b. Appointing Technical Strategists.

c. Approving Technical Strategies.

d. Approving Program Plans and related budgets.

e. Directing the allocation of funds.

Director of Technology Programs/Director of Navy Technology DTP/DNT. As DNT, this official is directly responsible to the ASN (R&D). As DTP, he is responsible to the DCNM(D)/CND. Acting for the CND, he is responsible for the planning, execution, and evaluation of the Exploratory Development Program. His functions include the following:

a. Designing a balanced and integrated overall Exploratory Development Program which maximizes the contribution of the Technology Base to the mission capability of Department of the Navy operating forces.

b. Developing and documenting the Exploratory Development Program Plan (EDPP) for review and approval by CND and ASN (R&D).

c. Nominating Technical Strategists and appointing Strategy Team members.

d. Reviewing and coordinating Technical Strategies.

e. Developing a Program-wide priority list for concept-related technical effort.

f. Negotiating Program Plans (and related budgets) with Systems Command Directors of Research and Technology (SYSCOM 03s) and with Technical Directors of the laboratories (Lab TDs), and recommending those plans to CND for approval.

g. Appointing Program Review Team leaders, and assisting in the staffing of Review Teams.

h. Scheduling and chartering External Program Review.

i. Conducting Program Reviews at the SYSCOM 03/Lab TD level.

SYSCOM Directors of Research and Technology (SYSCOM 03s). The SYSCOM 03s plan and execute that portion of the overall Exploratory Development Program related to System Concepts (SCs) and other products within the material responsibility areas of their SYSCOM. The general responsibilities of a SYSCOM 03 include:

a. Designing a balanced and integrated overall SYSCOM Exploratory Development Program which supports Objectives in the approved Mission Area Technical Strategies.

b. Documenting planned technical efforts in a Program Plan for negotiation with and approval by the DNT.

c. Prioritizing concept-related objectives set forth in the Program Plan.

d. Providing designated personnel to serve as Technical Strategists and as members of Strategy and Program Review Teams, as requested by DNT.

e. Negotiating and approving proposed TAPs.

f. Reviewing proposed changes in TAPs approving desired changes within his authority, and submitting desired changes beyond his authority to DNT for appropriate action.

g. Monitoring execution of his SYSCOM's technical program, and taking actions as appropriate.

h. Ensuring the Internal Review of his SYSCOM's program, and providing copies of Internal Review Reports to DNT.

Laboratory Technical Directors (Lab TDs). The Lab TDs plan and execute that portion of the overall Exploratory Development Program related to the development and utilization of technology within the areas of Laboratory responsibilities. The general responsibilities of the Lab TD include the following functions:

a. Designing a balanced and integrated overall Laboratory Exploratory Development Program which supports approved Technology Area Strategies.

b. Documenting planned technical efforts in a Program Plan for negotiation with and approval by the DNT.

c. Prioritizing technology-related objectives set forth in the Program Plan.

d. Providing designated personnel to serve as Technical Strategists and as members of Strategy and Program Review Teams, as requested by DNT.

e. Negotiating and approving proposed TAPs.

f. Monitoring execution of his Laboratory's Technical Program, and taking actions as appropriate.

g. Reviewing changes in proposed TAPs approving desired changes within his authority, and submitting desired changes beyond his authority to the DNT or SYSCOM 03 as appropriate.

h. Ensuring the Internal Review of his Laboratory's program, and providing copies of Internal Review Reports to DNT.

Responsibilities for preparation of Technical Strategies. Each Technical Strategy is developed and/or updated by a Technical Strategist and a supporting Technical Strategy Team.

Technical Strategists. A Technical Strategist is responsible for the development and updating of each Technical Strategy. Strategists report to DNT for all matters relating to their Technical Strategies. Technical Strategists may be recruited from any Department of the Navy organization; normally, however, they will be NAVMAT, Laboratory, or Systems Command officials "double hatted" to CND for this duty. The general responsibilities of Technical Strategists include:

a. Identifying Strategy Team needs with the appropriate knowledge and organizational affiliations.

b. Developing and/or updating the assigned Technical Strategy as required (with the aid of the Strategy Team).

c. Maintaining current knowledge of the Technical Strategy in general (and its MA or TA Objectives in particular) and of all relevant technical capabilities, current efforts, and planned efforts.

d. Reviewing all TAPs which purport to support Objectives listed in the Strategy, and taking appropriate actions to improve the effectiveness of technical contributions to higher-level objectives.

e. Serving as person-to-person channels between CND/DNT, Strategy Teams, and the technical community for the flow of needs information related to their Technical Strategies. This function includes helping technical personnel establish direct contact with individuals most knowledgeable about issues of interest.

Strategy Team. Strategy Teams are constituted so that they have within the Team the essential knowledge and expertise required for the development of the Technical Strategy--without reference to documents except for detailed information. Such representation, in addition to helping in the cost-effective preparation of an adequate Strategy document, is an essential element in the development and maintenance of the "people information system." Ideally, the Strategy Team includes members from organizations which both require information on the Strategy, and which are sources of information required in the development of the Strategy. Each Strategy Team should include individuals who served on the Team in prior years; this ensures the preservation of a paper-free institutional memory. MA Strategy Teams include members from all TA Strategy Teams for technologies critical to the attainment of the MA Objectives. Participation of these people provides a direct and paper-free injection of information on technological capabilities and potential capabilities into the development and updating of the Strategy, and a reverse flow of Mission Need information into the program planning and execution activities of their parent Systems Commands and Laboratories. TA Strategy

Teams include spokesmen for SCs which use subject technology, members from organizations developing subject technology, and representatives of the research community involved in developing the base of knowledge underlying the subject technology.

Source of Strategy Team members. Strategy Team members are recruited from both Government and the private sector. Department of the Navy technical organizations are directed to provide members to Technical Strategists on a negotiated basis. Assistance in recruiting non-Department of the Navy personnel will be provided by DNT (Attention MAT 03T3). Strategy Team members from Department of the Navy organizations are to be provided travel and analytical support by their parent organizations as required.

Program Review Teams. There are two kinds of Program Review: Internal Review and External Review (see Chap. IV). Internal Review Teams, under the leadership of the cognizant Laboratory Technical Director or SYSCOM 03, conduct self-reviews of all detailed technical programs. External Review Teams, under the leadership of a designated member of DNT's staff, conduct External Program Reviews at the Laboratory/SYSCOM level.

Staffing the Interval Reviews. SYSCOM 03s and Laboratory Technical Directors are responsible for determining the size and make-up of each Laboratory or SYSCOM Internal Review Team, and for assigning individuals from within their respective organizations to serve as Team members. TD/SYSCOM 03s also have the option of recruiting Team members from outside their organizations.

Staffing External Reviews. Two primary considerations determine the staffing of External Review Teams: (1) Team members should be qualified to verify the validity of Internal Review information without reference to additional documentation, and (2) the External Review Process should establish a "people information system" which contributes to the effective planning and execution of the overall Program. The DNT-chartered External Program Review Team is a broad-based *ad hoc* group. DNT appoints an External Review Team leader from his staff; he also appoints other Team members from among interested and qualified Navy and non-Navy organizations. External Review Team members include: (1) current and/or former members of relevant Strategy Teams, (2) DNT staff members, (3) members of previous DNT Program Review Teams (to ensure the preservation of a paper-free institutional memory; these individuals can note what has been done about deficiencies discovered in previous External Program Reviews), (4) representatives of organizations which supply inputs to the programs under review (e.g., ONR Scientific Officers for disciplines critical to the technologies involved), (5) representatives of organizations which use the outputs of the programs under review, (6) technology managers who conduct similar programs, and (7) experts from the wider technical community, including industry. Externnal Program Review Team members are important links in the paper-free "people information system."

DNT Staff. The DNT staff provides the DNT with supporting services, information, and counsel required for effective

performance of DNT's Exploratory Development Program management functions. Individual staff members are assigned cognizance over specific matters--such as individual Technical Strategies, Laboratories and SYSCOMs and their related Program Plans, and Program Elements. Specific duties of these cognizant staff members are discussed below.

Technical Strategies. Duties of the DNT staff members assigned cognizance over a Technical Strategy include:

a. Achieving and maintaining in-depth knowledge of the Technical Strategy, its rationale, and of all on-going or planned technical effort supporting Objectives in the approved Strategy.

b. Serving as a member of the Strategy Team for that Strategy.

c. Providing staff services for the recruitment and assignment of Strategy Team members, in compliance with staffing requirements developed by the Technical Strategist.

d. Alerting the DNT to developments or trends related to the Strategy which require DNT's attention.

Organization and Program Plans. Duties of DNT staff members assigned cognizance over technical organizations and related Program Plans include:

a. Achieving and maintaining in-depth knowledge of the planning and execution aspects of the organization's technical program--including all changes to the originally approved program.

b. Reviewing proposed Program Plans and providing DNT with appropriate information and counsel.

c. Serving on the Program Review Team (as leader or member).

d. Determining requirements for Review Team personnel, and taking necessary actions to facilitate the recruitment and assignment of appropriate personnel.

e. Alerting the DNT to developments or trends related to the organization (or its Technical program) which require DNT's attention.

f. Providing oral and written information about the organization and its program to Government officials and private sector individuals with a need to know.

<u>Program Elements</u>. Duties of DNT staff members assigned cognizance over a Program Element include:

a. Achieving and maintaining in-depth knowledge of: (1) planning and execution aspects of work included within the Program Element, (2) technical objectives and supporting rationales for the work performed, and (3) all actions and policies of higher level officials, including the Congress, related to the Program Element.

b. Preparing Program Element Descriptions (PEDs) and any other documentation required in connection with the annual budget submission, apportionment process, Congressional hearings, etc.

c. Preparing PE-level TAP Aggregates using TAP information approved by SYSCOM 03s and Lab TDs (and by DC/S RD&S and CG MCDEC for Marine Corps programs).

d. Alerting DNT to developments or trends related to the Program Element which require DNT's attention.

e. Providing information, both orally and in writing, concerning the Program Element to Government officials and private sector individuals with a need to know.

Interfacing Responsibilities. Other organizations and individuals outside of the Naval Material Command play significant roles in the Exploratory Development Program.

Congress. The Congress provides the funds for the 6.2 Program and establishes funding controls at the Program Element level. Congress may, on occasion, control the funding of individual projects. Management responsiveness to Congress, credibility of information, and utility of results are essential to continued stability of the Navy's Program.

Director of Defense Research and Engineering (DDR&E). The DDR&E exerts influence at all levels of the Program. He can compare the management and technical content of the Exploratory Development Programs of all Services, and can direct all technical programs in an area to be assigned to one Service. The DDR&E is the dominant DoD agency in the justification of work and the budgeting of funds.

Assistant Secretary of the Navy (Research and Development (ASN(R&D)). The ASN (R&D) is responsible for the RDT&E(N) appropriation, and for the planning and execution of the entire

Department of the Navy RDT&E Program (including Exploratory Development). ASN (R&D) reviews and approves the various versions of the EDPP on an exception basis. He is also charged with justification of the Navy EDP to DDR&E and Congress. The small ASN (R&D) staff relies heavily on the CND and his staff for information and presentation of the program. Close working relationships and mutual confidence between CND/DNT and the ASN (R&D) are essential.

Chief of Naval Operations/Commandant of the Marine Corps (CNO/CMC). The CNO and CMC influence the 6.2 Program by establishing operational needs and by directly sponsoring Advanced and Engineering Development. As the primary markets for the Program output, the CNO/CMC must be satisfied with its military relevance. The CND, assisted by the SYSCOMs, interprets the operational needs described by CNO/CMC in the Technical Strategy documents. The subsequent discussion, understanding, refinement, and definition of operational needs lead to development and acceptance of a useful product. CNO/CMC review all SCs when they are first submitted, and annually as long as they are included in the Program. CNO/CMC estimate the military worths of all SCs and assign them quantitative military worth ratings, "V" ratings, for use in planning Technical Strategies and supporting technical programs.

Chief of Naval Research (CNR). In addition to his responsibilities for the Naval Research Program, the CNR is responsible for sponsoring these exploratory development projects

which are necessary to ensure orderly transition from research to development. For the projects which he sponsors, CNR functions like a Systems Command.

Chief of Naval Personnel (CNP) and Chief, Bureau of Medicine and Surgery (CHBUMED). CNP/CHBUMED are the primary sponsors for Exploratory Development relative to the human subsystem and to medical and dental systems. They are understood throughout this instruction to function like a Systems Command in these areas.

Industry/Academia. Industry and educational institutions interact principally at the SYSCOM and Laboratory levels. They provide Laboratories and SYSCOMs with assistance, on a contract basis, in developing both technologies and products.

APPENDIX B

EXPLORATORY DEVELOPMENT PROGRAM DOCUMENTATION

The documentation for planning and justifying the Exploratory Development Program is described in this appendix. The basic document through which the Chief of Naval Development (CND) and the Director of Navy Technology (DNT) control the Program is the Exploratory Development Program Plan (EDPP). The EDPP is supported by Technical Strategy documents, Laboratory and System Command Program Plans, and Systems Concepts (SCs).

<u>Exploratory Development Program Plan (EDPP)</u>. The EDPP is <u>the</u> authoritative statement of the content and rationale of the Navy's Exploratory Development Program. It defines the major thrusts of the overall Program, identifies major Program goals, and apportions resources among all elements of the Program. Further, it summarizes and provides an integrated overview of the Technical Strategies and the supporting Laboratory and Systems Command Program Plans. The EDPP is prepared by the Director of Navy Technology (DNT) on the basis of: (1) budget and program guidance from higher authority, (2) Technical Objectives developed by the Strategy Team, (3) Program Plans developed by Laboratories and SYSCOMs, and (4) Internal and External Program Review Reports. The EDPP is continually updated to reflect changes in these inputs.

<u>Technical Strategies</u>. Technical Strategies serve two major purposes: They effectively relate the Exploratory

Development Program to Department of the Navy Mission Needs, and they make that relationship visible and credible.

Functions of Technical Strategies. Technical Strategies have both direct and indirect functions.

Direct Functions. Technical Strategies are designed to: (1) take maximum advantage of new technical opportunities, (2) exploit deficiencies in opposition capabilities, and (3) provide prompt response to perceived requirements for superior naval capability.

Indirect Functions. Strategies provide the vehicle for a two-way information flow on needs and technological capabilities (and possibilities). They also serve as the means for demonstrating the general rationality--and specifically the mission-relevance in output-oriented terms--of the Exploratory Development Program.

Kinds of Technical Strategies. There are two kinds of Technical Strategies: those which relate to the Mission Areas for which the Navy has responsibility and those which relate to the Technology Areas which are basic to the Navy's operational capabilities.

Mission Area (MA) Technical Strategies. MA Technical Strategies directly link the Exploratory Development Program to the major missions of Department of the Navy operating forces. MA Strategies are developed for assigned Mission Areas or for established segments of Mission Areas. Since MA Strategies are designed both to relate the Program to

operational missions, and to facilitate understanding of that relationship by officials and organizations with influence over the Department of the Navy Program, MA Strategy Areas are structured to be compatible with the structure of Mission Areas used by DDR&E in the Mission Area Summaries (MAS).

Technology Area (TA) Technical Strategies. TA Technical Strategies set forth objectives for technology and the supporting rationales. The structure of areas for which TA Strategies are developed is also derived from the DDR&E mission Area Summaries. TA Technical Strategies so defined are also compatible with the Technology Coordinating Papers (TCPs) issued by the OSD.

Preparation of Technical Strategies. Preparation of both MA and TA Technical Strategies involves the identification and evaluation of needs, and the identification of present, future, and potential capabilities for satisfying those needs. All Technical Strategy documents employ a similar format. Each describes the relevant Strategy Area (this will be either a Mission Area or a Technology Area), sets forth Objectives and the supporting rationales, identifies how Objectives in the Strategy Area are being pursued currently, and references sources of additional information.

Mission Area (MA) Technical Strategies. In general, each MA Technical Strategy sets forth: (1) Mission Area Objectives for the Mission Area, (2) the supporting rationales for those Objectives, and (3) a discussion of present and future

exploratory development efforts relevant to MA Objectives. Preparing MA Technical Strategies requires a comprehensive understanding of operational needs.

Mission Need Information. Mission Need information is available through both formal and informal systems. Information on operational needs is provided primarily through an informal face-to-face system based on and backed up by a document-based system. Information on needs is derived from a variety of sources including Fleet letters, CNO memoranda, extrapolation of threat statements, etc. Mission Need information flows through the Navy/Marine Corps organization to the Exploratory Development Program by means of three formal documents: the Navy Science and Technology Objectives (STOs), the Marine Corps General Operational Requirements (GORs), and the Operational Requirements (ORs). The first two documents are aimed primarily at guiding the inception of projects and programs (although guidance may be derived from them at any point in the process). The Operational Requirements (ORs) are concerned with the transition of System Concepts to Advanced Development.

Mission Area Objectives. MA Objectives are objectives for operational capabilities within the Strategy Areas. They are set forth as means-free statements of needs for operational capabilities required to execute the mission. These statements are prepared in a manner which satisfies the requirements for statements of Mission Needs for the initiation

of major system acquisitions as set forth in OMB Circular A-109 and implementing DOD directives and instructions. MA Objectives should be considered identical to the Mission Element Need Statements (MENS) defined in DOD Directive 5000.1 and should conform to the format specified in Appendix D. All MA Objectives are to be numbered in a manner which facilitates the information capabilities discussed in 4.6. The rationale for each MA Objective should be explained clearly and concisely and should reference all official documentation (such as STOs and GORs) on which it is based in whole or in part.

Actual and Potential Capabilities. Associated with each MA Objective is a discussion of means for satisfying the Objective. This discussion consists of a concise description of each system, System Concept, or other way (such as a combination of forces) to satisfy the Objective, along with references to primary sources of additional information. Additionally, capabilities relevant to each Mission Need are to be identified and summarized briefly. These include present capabilities, systems in development or production but not yet operational, and Demonstrated-feasible, Presumed-feasible, and Pre-feasible System Concepts (SCs). All SCs will include military worth ratings by CNO and/or CMC. The listing of Demonstrated-feasible SCs will also identify concepts which were dropped since the last update of the Technical Strategy.

Technology Area (TA) Technical Strategies. Each TA Technical Strategy: (1) Describes current technical efforts and relates these to identified Mission Needs, (2) sets forth Objectives for technology and the supporting rationales of those Objectives, (3) justifies the importance of technical opportunities and potential advancements in output-oriented terms, and (4) explicitly summarizes and presents justifications for present, future and potential technological capabilities by specifically referencing relevant SCs. TA Technical Strategies are developed and/or updated in a manner analogous to the process described above for MA Technical Strategies. The process involves defining Technology Needs, setting forth the rationales for those needs, and describing present, future, and potential capabilities relevant to identified Objectives. A Technology Area is concisely defined in terms of the technologies included within its scope. Where further clarity is needed, a Technology Area may be further defined by identifying related technologies beyond its scope.

Technology Need Information. Technology Need information is derived from three principal sources: (1) the systematic analysis of Pre-feasible SCs, (2) feedback from the development and manufacturing processes, and (3) feedback from the operating forces. Information from analysis of SCs takes the form of documented statements of technological problems or barriers; feedback information flows primarily through person-to-person links and is introduced into the Strategy deliberations most frequently through the personal experience of Strategy Team members.

Technology Area Objectives. Objectives for technological capabilities are set forth as statements of needs for technological capabilities, termed Technology Area Objectives, or TA Objectives. These are statements of needs both for the development of new technological capabilities in support of SCs, and for the preservation of a base of technology underlying present operational capabilities (where it is judged that such a technology base would be endangered in the absence of action to preserve it). TA Objectives are numerically identified in a manner which facilitates the information capabilities discussed above and in 4.6. The rationale for each TA Objective should be set forth clearly and concisely and should reference all official documentation (such as technological problem statements from analyses of SCs) on which it is based. Every rationale should present a convincing case which describes how the Objective is critical either to achievement of higher level of mission capability or to the preservation of capabilities which would be endangered in the absence of actions the Objective is designed to stimulate.

Actual and Potential Capabilities. Technological capabilities relevant to each TA Objective are identified and summarized briefly, as are the rationales for each of those capabilities. These include statements and rationales for current capabilities, for capabilities anticipated on the basis of planned technical effort, and for capabilities which are potentially achievable if a specified level of technical

effort is assumed. The accompanying discussion identifies the leading organizations possessing, acquiring, or capable of acquiring the capabilities. Relevant ongoing or planned technical programs are identified, and their predicted impacts on capabilities are specified.

Program Plans. Program Plans are the primary instruments through which the DNT exerts top-down influence over portions of the Exploratory Development Program assigned to each SYSCOM and Laboratory. Program Plans document each SYSCOM's or Laboratory's integrated and balanced plan for maximizing the contribution of its own exploratory development efforts to Department of the Navy needs. Program Plans are not collections of Task Area Plans (TAPs). (TAPs are prepared after the Program Plans are approved and are designed to carry out objectives listed in those Plans.) Analogous to a DCP for approval, funding, and management of an acquisition program, the Program Plan constitutes a "contract" between DNT and the SYSCOM 03/Lab TD for the Laboratory/SYSCOM portions of the 6.2 Program. The Program Plan is the basis for the negotiation, approval, funding, and subsequent review of each SYSCOM's and Laboratory's Exploratory Development Program. The content and format for Program Plans are summarized briefly below.

Technology Needs and Thrusts. This section will provide an introduction and overview of the proposed technical program, setting forth the major thrusts of the program and the

rationale for those thrusts. It will also discuss significant changes from past years and the rationale for those changes.

Program Objectives. The technological objectives the technical program is designed to achieve will be set forth, as will the rationale for those objectives. These objectives are to be stated in quantitative terms (to the extent possible) to facilitate subsequent review of results. The rationale for objectives should explicitly identify the approved Technical Objectives which the program objectives are designed to support.

Proposed Program. The technical program to achieve each program objective will be briefly described in both narrative and quantitative terms. This description should include the proposed dollars to be spent in support of each program objective, the prospective performing institution(s), and major milestones scheduled for achievement during the program year.

In-House/Contract Ratio. The program plan will specify the relative proportions of work to be performed by Government organizations (in-house) and by industry and other non-Government organizations (under contract). The DNT will negotiate the in-house/contract ratios with each SYSCOM and Laboratory to ensure that the overall Program conforms to the most recent policy guidance.

Program Turnover. Ongoing efforts should be critically reviewed and sufficient work completed or terminated, to permit a minimum of 20% of the technical program to be composed

of new starts. The Program Plan will specify the percentage of the program which is new, and will identify efforts being completed or terminated.

Priorities. The technical program will be organized into decision packages corresponding to discrete elements of the proposed program (such as all work related to specific System Concept or Laboratory subproject). These decision packages will be presented, along with cost information, in a rank ordering. This is intended to facilitate the elimination, or addition, of entire projects (rather than to make across-the-board funding reductions which could result in subcritical funding and the inefficient use of resources). Rank ordering also facilitates the phased initiation of new starts to accommodate Congressional budget actions and deferrals of funds.

System Concepts. Priority rankings for SYSCOMs will be organized around the SCs which are the objectives of SYSCOM efforts. Information to be presented will include:

a. A master rank-order of all ongoing and new starts of all three classes of SCs.

b. A rank-order of both ongoing and new starts for each of the three classes of SCs.

c. A rank-order for proposed new starts for each category of SC.

Laboratory Subprojects. The proposed Laboratory program will be presented as a master rank-ordered list of subprojects and will include ongoing work and proposed new starts.

System Concepts (SCs). An SC is a System Concept for satisfying one or more MA Objectives. SCs provide a mechanism for: (1) identifying technology needs, (2) focusing technical effort on the technological advances required to make these high-leverage system concepts feasible, and (3) aiding transfer of that technology to development once technical feasibility has been achieved. Although normally originated by Laboratories, Systems Commands, or industry, SCs may be originated by any organization. Instructions for the documentation of SCs are contained in Appendix E.

Classes of System Concepts. SCs fall into three classes: (1) concepts presumed not yet technologically feasible without advances in underlying technology, (2) concepts presumed to be technologically feasible within five years but for which feasibility has yet to be demonstrated, and (3) concepts presumed ready for transition to development. Each of these three classes of SCs serves a different function in the management of the Exploratory Development Program. All classes of SCs provide a basis for the assessment of a concept's military worth; this is an essential prerequisite to the further investment of technological resources (beyond the investment required to define concepts sufficiently to permit meaningful military worth assessments).

Pre-Feasible System Concepts. Pre-feasible SCs provide a basis for identifying and defining technology which must be developed before these concepts become technologically feasible.

When communicated to the technical community involved in developing broad-based technology, these technological requirements stimulate development of the requisite technology. Pre-feasible SCs (and their related requirements for advancements in technology) are an essential link in the relevance audit trail; they make it possible to demonstrate the direct relevance of technical effort in the broad-based technology category to operational missions.

Presumed-Feasible System Concepts. SCs for which feasibility has been presumed but not yet demonstrated provide the framework for: (1) defining the requirements for feasibility demonstrations, and (2) organizing related data. Demonstrating the feasibility of an SC can be likened to assembling a technological building block kit. As feasibility is demonstrated for each essential technology, it is added to the kit until all essential building blocks are in hand. At that point the concept becomes a "Demonstrated-feasible SC" and is ready for transfer to further development.

Demonstrated-Feasible System Concepts. Demonstrated-feasible SCs which are not immediately transferred to development may be dropped, or, they may be preserved as options for future development (depending upon the military worth assessment of the system user). Where a decision has been made to preserve the option to develop, the SC provides the framework for the preservation of that option. The development option is preserved by continually: (1) monitoring

relevant technologies, (2) updating the information package to include current capabilities, and (3) identifying organizations which possess the needed capabilities.

Assessment of the Military Worth of SCs. The CNO and CMC are invited to assess periodically the relative military worths of all SCs related to each MA objective in their areas of warfare. These military worth ratings, termed "V" ratings for value, are to be included in the discussion on MS Objectives in the Technical Strategy documents.

Task Area Plans. Detailed plans for accomplishing the objectives in approved Program Plans are summarized in Task Area Plans (TAP). Since program plan objectives are designed to support objectives in approved Technical Strategies, the Strategies provide amplifying guidance for the development of these more detailed plans.

Information System. Because of the direct relationship between Technical Objectives called out in the Technical Strategies and objectives defined in the Laboratory and SYSCOM Program Plans, a relevance audit trail extends from each work unit to each assigned Department of the Navy mission. When the information system mandated by paragraph 4.b. of ASN (R&D) memo of 25 July 1975, "Management of the Exploratory Development Program," is developed and in successful operation, it will be possible to make these relevance relationships visible through automatic data processing. An ADP query starting with a Mission Need will be able to identify all MA

Objectives called out in the MA Technical Strategy for that area, all Technology Area Objectives in support of MA Objectives called out in any of the TA Technical Strategies, all program objectives which support the MA Objectives either directly or indirectly through TA Objectives, and all work units supporting these program objectives. Going the other way, ADP capability based on the structure of objectives extending upward from the technical program, through the Technical Strategies to Department of the Navy missions, will make it possible to trace the impact of each work unit on higher-level objectives and Mission Needs.

APPENDIX C

STRUCTURE OF THE EXPLORATORY DEVELOPMENT PROGRAM

The Chief of Naval Development (CND) establishes and promulgates the structural framework for planning, programming, and budgeting the Navy's Exploratory Development Program. This structure provides a link with DOD Program Elements, defines the scope of work within specific areas, and identifies the organization within the Navy responsible for planning, programming, and budgeting.

Building Blocks of the Exploratory Development Program. The building blocks of the Exploratory Development Program are described in the following paragraphs. They are listed in descending order, from the largest block to the smallest.

Program Elements. Program Elements are the smallest subdivision of the R&D program considered in the DOD programming system. A program is defined as an integrated activity, an identifiable military capability; a force, support activity, research activity, etc., comprising a combination of personnel, equipment, and facilities. In exploratory development, a Program Element consists of a number of projects in a related field within a single budget activity.

Program Groups. Program groups are primary divisions within the Navy exploratory development planning system. They are used for management and data-processing purposes, and provide the links between the Navy planning system and the

Program Elements of the DOD system. They correspond one-to-one with the Program Elements--with the exception of Groups 54 and 55, each of which corresponds to two Program Elements and thus requires the project area number to relate a component effort to the correct Program Element. The program groups are as follows:

Program Group #	Program Element Title	Program Element #
11	Undersea Target Surveillance	62711N
12	Surface/Aerospace Target Surveillance	62712N
21	Command and Control	62721N
31	Missile Propulsion	62331N
32	Strike Warfare Weaponry	62332N
33	Undersea Warfare Weaponry	62633N
34	Countermeasures	62734N
41	Aircraft	62441N
42	Nuclear Propulsion	62542N
43	Ships, subs and boats	62543N
51	Biomedical Technology	62758N

Program Group #	Program Element Title	Program Element #
52	Ocean and Atmospheric Support Technology	52759N
53	Logistics Technology	62760N
54	Materials	62761N
54	Electronic Devices	62762N
55	Training and Human Engineering	62757N
55	Personnel Support Technology	62763N
56	C/B Weapons Defense	62764N
57	Energy and Environmental Protection	62765N
61	Laboratory IED	62766N

Functional Area. The functional areas are the five principal headings under which exploratory development is classified for program planning purposes. These functional areas are:

100 - Target Surveillance

200 - Command and Control

300 - Weaponry

400 - Naval Vehicles

500 - Support Technology

Project Areas. Project areas further subdivide the functional areas, as shown in Appendix and serve to group closely-related task areas.

Projects. Projects encompass the aggregate of task areas under a given project area which fall within a single program group (therefore usually within a given Program Element).

Subprojects. Subprojects encompass the aggregate of task areas within a project which are assigned to a single principal development activity. Development activity identifying codes are as follows:

Activity	Code
NAVAIRSYSCOM	W
NAVELEXSYSCOM	X
NAVFACENGCOM	Y
NAVMEDRSCHDEVCOM	M
ONR	R
NAVSEASYSCOM	S
NAVSUPSYSCOM	T
DLP	Z

Task Areas. Task areas encompass exploratory development effort directed toward a specific objective, e.g., thrust-controlled solid rocket. Task areas are the level at which detailed plans are prepared. These plans are available to the Chief of Naval Development as back-up data for justification of the Program to higher authorities, if needed. A task area may consist of one or more tasks and be assigned to an individual Laboratory, Systems Command, or Office of implementation.

Tasks. Tasks are subdivisions of task areas established on the basis of organizations performing the work. They are used for internal Department of the Navy management only. Specific task assignments are made for the portion of the

work under a given task area to be contracted or to be assigned to an individual Laboratory or field activity. A task may consist of one or more work units.

Work Units. Work units are the smallest segments into which research and technology efforts are normally divided for purposes of local administration. In the Exploratory Development Program, work units are subdivisions of a task selected by the organization performing the work to provide effective local technical control and supervision. A work unit is technically distinguishable in scope, objective, and/or approach from other scientific or technical efforts with which it may be aggregated for financial or administrative purposes.

Numbering System. Based upon the building blocks described above, the numbering system applied to specific development efforts within the Exploratory Development Program is designed to permit ready identification and retrieval of information regarding any portion of the Program. An example of the use of the system is shown below:

An Exploratory Development effort . . . . . F
in the "Missile Propulsion" Program Group 31
in the "Weaponry" Functional Area 300
and specific Project Area "Solid Propulsion 332
has Project Number . . . . F 31 332
The portion performed by NAVAIR . . . . W
has Subproject Number . . . . WF 31 332

A part of the effort is directed in the

Task Area "Thrust Controlled Solid Rocket" 302

and has Task Area Number . . . . WF 31 332 302

Within the Task Area are Tasks, and within

the Tasks are Work Units designated by

three-character identifiers established

respectively by the SYSCOMs and Labs . . . . xxx yyy

So that the entire number identifying a

Work Unit would be . . . . WF 31 332 302 xxx yyy

Work Unit Number

Task Number

Task Area Number

Sub project Number

Project Number

W	F	31	332		302*	#	#
Devel-oping Activity (NAVAIR)	Program (Explora-tory Devel-opment)	Program Group (Missile Propul-sion)	Func-tional Area (Weaponry)	Project Area (Solid Propulsion)	Task Area (Thrust Control-led Solid Rocket	Task	Work Unit

*The three digit number and identifier assigned by SYSCOM/Laboratory

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